The Journal of THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

Vol. 17 DECEMBER, 1951 No. 4

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Vol. 17 **No. 4**

DECEMBER, 1951

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Published Quarterly. *Annual Subscription Rate: Within Australia* 10/6, *British Countries* 11/6, *Foreign Countries* 12/6.

Quotation from this Journal in whole or in part is permissible provided due acknowledgment is made.

ARTICLES

THE GROWTH AND REGENERATION OF EUCALYPTS

By M. R. JACOBS

Summary

The vegetative characters responsible for the nature of eucalypt growth in Australia and overseas are described. More rapid growth overseas is considered to be due to the absence of leaf-eating insects. In most parts of Australia the eucalypts do not grow quickly from seedlings, but spend some years in an apparently suppressed condition while the root systems obtain a grip on the soil. They are enabled to do this by their lignotubers. The nature of regeneration in forest and pasture land is discussed.

Introduction

The genus *Eucalyptus* is renowned outside its homeland for the extraordinary rate of growth of many species. Within Australia, even though growth is not slow by world standards, the genus is more remarkable for the general hardiness of the trees and the persistence of regeneration than for rate of growth.

The effect on human activities of the hardiness of the trees and the persistence of regeneration can be both favourable and unfavourable. On the one hand these factors have given Australia tree covered land in very difficult localities. On the other hand the persistence of regeneration sometimes gives graziers the problem of repeated clearing. In summer rainfall regions eucalypt regeneration often becomes a limiting factor in the establishment of pastures.

This paper describes some of the vegetative characteristics of the eucalypts responsible for the nature of their growth and regeneration. It shows how such features as remarkable growth overseas, slower growth at home, hardiness and persistence are inter-related. The paper is partly a review of literature on the subject, and partly a summary of observations made by the writer as a Research Officer of the Commonwealth Forestry and Timber Bureau and Lecturer in Silviculture at the Australian Forestry School.

THE LEAF-BEARING SYSTEMS OF THE EUCALYPTS

The eucalypts can make use of four ways of forming leafy shoots, and all of them are significant in problems of growth and regeneration. They are:—

a. Branches arising from naked buds

If a young eucalypt is examined early in the growing season, a growing tip on a fairly long tender stalk may be observed in the axil of each new leaf. These growing tips are illustrated in Figure 1 (A1). The writer has called them "naked buds" (Jacobs, 1936). The naked buds are capable of rapid extension in length from the day the mother leaf unfolds until suitable conditions no longer exist. In the course of growth they throw off leaves at intervals of about one or two inches. In the axil of each of these new leaves there is also a naked bud which can continue the growth pro-

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cess. With the help of this mechanism the eucalypts are able to accomplish extraordinary feats of growth under favourable conditions. They can develop several orders of branches within a few weeks, and thus build up a large crown very quickly. Trees of many other genera can make only one order of branches each year because the buds in the leaf axils are not able to unfold until the year following that in which they are formed.

The naked buds are the secret of the remarkable rate of growth achieved by eucalypts outside Australia; the slower growth at home is due to the fact that in Australia the naked buds are so frequently destroyed by leaf insects. In most parts of the country there are only a few weeks, early in the growing season, when the naked buds can act with full efficiency. Then the leaf-eating insects appear and the buds are quickly attacked. The growth potential of the tree is reduced because it can no longer take advantage of the power inherent in it to make the most of good growing conditions.

The insects which destroy the naked buds and leaves of eucalypts appear to have evolved concurrently with the genus in Australia. These insects are not found overseas where the gum tree is so renowned for its growth. There the eucalypt crowns develop mainly from naked buds, and they are noticeably different in structure from the crowns usually seen in Australia. Several Australian workers on the genus have found it difficult to recognise the overseas crown outline of some of the well-known trees. Long festoons of branches on which every leaf is perfect may be seen on species which in Australia are characterised by short branches poorly covered by rather "moth-eaten" leaves. No wonder there is a difference in rate of growth!

Examples of very rapid growth of eucalypts can be quoted from Australia. Near Coff's Harbour, N.S.W., the writer has followed the development of a plantation of *E. grandis* (Flooded Gum) where the biggest trees grew 40 feet in height in two years from the date of planting. This growth took place in a rich valley where there had been a particularly fierce slash burn. The burn seemed to reduce the population of leaf-eating insects. For the two years of very fast growth there was little interference with the succession of branches produced from naked buds. Three years later the same plantation was nearly defoliated. Later again the balance of nature settled down and the growth proceeded "normally". Other cases have been observed of this sequence, namely:—

(i) Fierce fire.

(ii) Rapid growth from naked buds.

(iii) Epidemic attack of insects and severe setback to growth.

(iv) "Normal" insect population and growth.

If a method could be found of controlling leaf-eating insects the efficiency of the eucalypts in their homeland would be appreciably increased. It should be stressed that insects eat the leaves of eucalypts as well as the naked buds (see Figure 1 (B)).

b. Branches arising from accessory buds

The naked buds are only the first of the potential branch-forming mechanisms in the genus *Eucalyptus*. At the base of each naked bud there exists an accessory meristematic region which may or may not be organised into a recognisable growing tip. As long as the naked buds and stem leaves are undisturbed these accessory meristematic regions are inhibited from developing by growth hormones produced in the naked buds and stem leaves. However, if the naked buds and part of the stem leaves are destroyed, this inhibition is removed, and one or more accessory growing tips will appear in each leaf axil. The time taken for

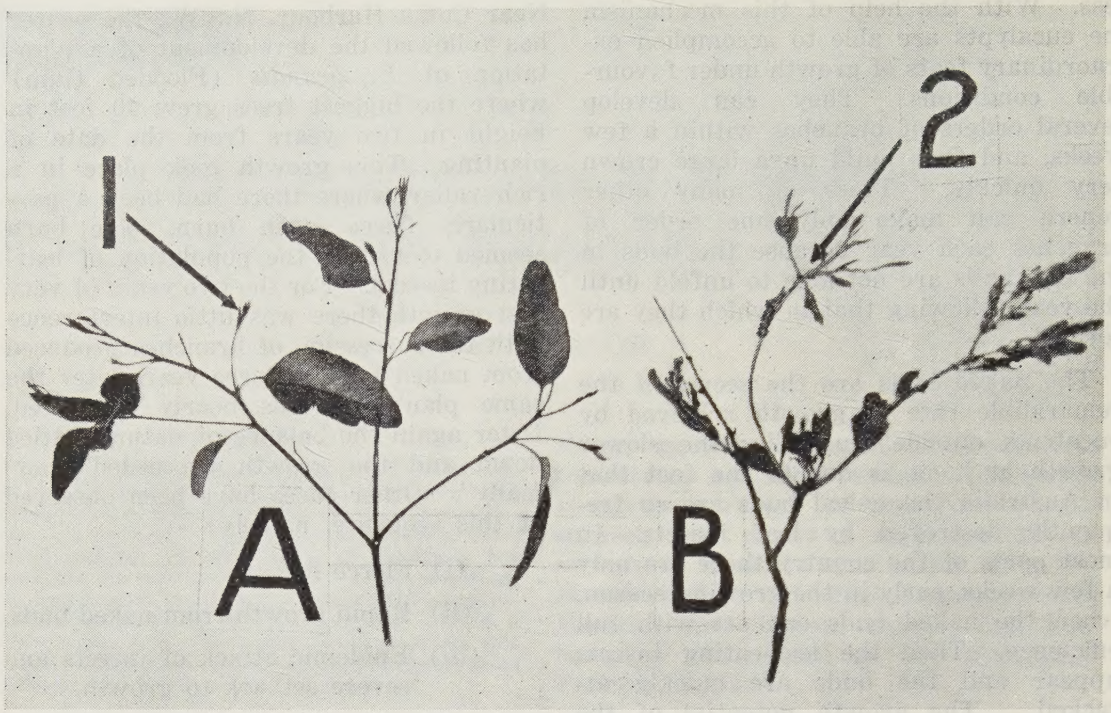

Figure 1.

the replacement of the original naked buds is only a week or two, and, once formed, the new axillary shoots have the same growth potential as the original naked buds.

Should the new shoots be destroyed, further shoots will develop and this remarkable replacement process may be repeated several times in a season. If the original naked buds only are destroyed, the check to growth in a season is noticeable but not marked. Unfortunately, once leaf-eating insects appear, they tend to remain for several weeks at least, and the benefit of a considerable proportion of a growing season is lost by repeated attacks on new growing tips.

The naked buds are the primary cause of the amazing rate of growth of eucalypts in the absence of insect parasites. The accessory buds are one of the reasons for the hardiness and persistence of the genus.

Shoots from accessory buds formed after insect attack are shown in Figure 1 (B2). These buds were called "concealed buds" by the writer to contrast them with the naked buds (Jacobs, 1936).

c. The proventitious buds

The meristematic tissue at the base of the naked buds may or may not produce new shoots according to whether the inhibiting effect of the naked buds and leaves, is removed or not. However, irrespective of the fate of the naked buds and leaves, the leaf-producing potential of the meristematic tissue in any leaf axil is not lost to a eucalypt as long as the branch which produces the leaf axil remains alive on the tree. The only exception is where part of a stem containing a given leaf axil is killed by some outside agency such as fire. In all other cases a small shaft of tissue with meristematic properties grows radially outwards from the leaf axil as the stem in-

creases in size. This shaft extends in length at the same rate as the radius of the stem increases, so that its terminus is at the wood surface or in the live bark. Each shaft is capable of producing leafy shoots, but its potentialities are normally held in check by the inhibiting effect of the growth substances produced by the crown of the tree above it. If the crown of the tree is lost or weakened by fire, insects, or even drought, this inhibition is removed and a bunch of several shoots may grow from one or many of these meristematic shafts on the tree trunk. The phenomenon is commonly seen after fire has passed through a eucalypt forest. When it is realised that there is at least one meristematic shaft on a eucalypt trunk for every leaf that was formed on the trunk as the tree gained height, it will be seen what a wonderful reserve these shafts represent, and how much they increase the hardiness and persistence of the genus.

The meristematic shafts were called "epicormic bud strands" by the writer (Jacobs, 1936), and the buds and shoots that grow from them "epicormic" or "proventitious" buds and shoots. The correct botanical term is "proventitious" to contrast them with true "adventitious" buds. The epicormic bud strands may be seen on the tangential section of tree trunks as little eye-shaped structures, and on the radial sections as shaft-like structures rather like large medullary rays. Figure 2 (A), shows the appearance of a strand on the wood surface of a tree, Figure 2 (B) a tangential section within the tree, and Figure 2 (C) a radial section. In Figure 2 (C) the arrow points to an epicormic bud strand, which is seen to come from the region of the pith at the base of a branch. The branch, of course, developed in a leaf axil.

Where bunches of proventitious shoots are produced along a eucalypt trunk after

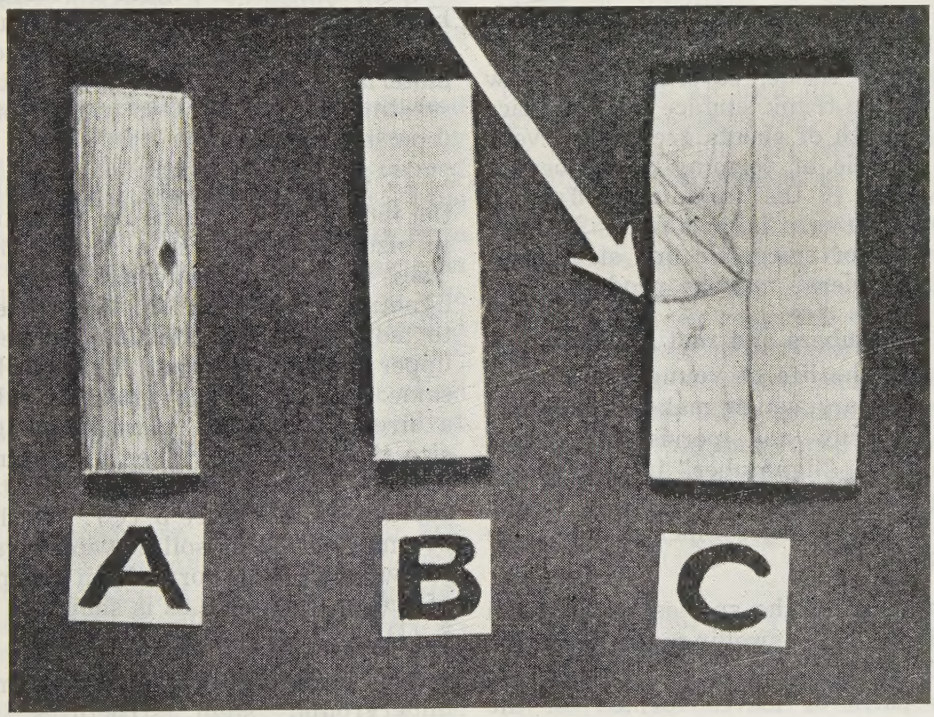

Figure 2.

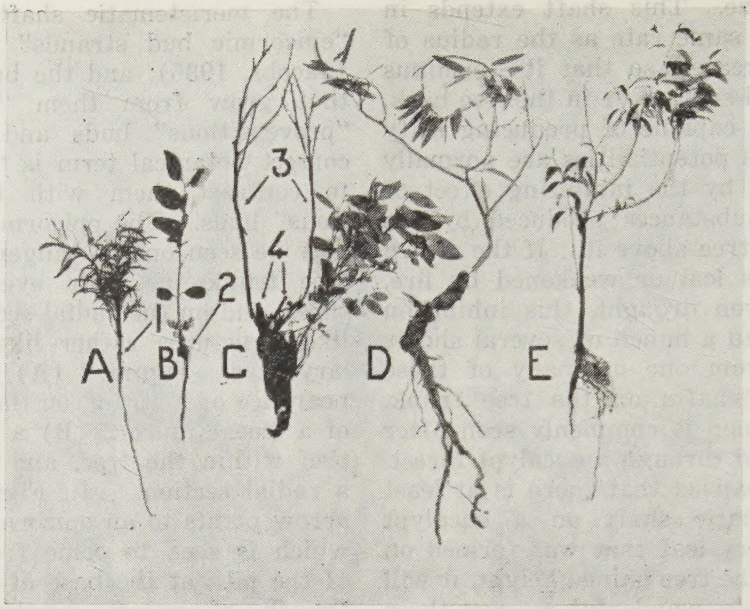

Figure 3.

defoliation, the upper ones succeed and the lower ones gradually become suppressed. This leads to a further example of how damage increases the persistence of the eucalypt. Instead of one shaft of meristematic tissue, several shafts now appear on the trunk surface at each place where a bunch of shoots grew, and every one is capable of forming a number of leafy shoots if the inhibiting effect of the upper crown is removed. In this way groups of epicormic bud strands of different "orders" may be produced.

d. The lignotubers and root swellings

Early in the life of young eucalypts a feature appears which makes them particularly hardy and persistent. This feature is the "lignotuber" in the case of most species, and a root swelling in the case of the few species which do not make lignotubers.

In the case of the species which form lignotubers, little swellings form in the axils of the cotyledons or of the first pair or two pairs of leaves formed on the seedling. This feature develops at a time varying from a few weeks to a few months after germination. The swellings are shown in Figure 3 (A1). They have the power to make leaf buds and in addition they store reserve food materials. Should the upper part of the seedling be destroyed it will shoot again from the swellings.

As the seedling ages the swellings in the individual leaf axils fuse and increase in size, as is shown in Figure 3 (B2). They form a bulbous mass aptly termed lignotubers by Kerr (1925). They tend to move down the stem and envelop the upper part of the root in somewhat the same way as callus growth folds over a fire scar. With increasing age and size they may bury themselves until the greater part of them is below the soil surface, as in Figure 3 (C). If the stem becomes buried by soil movement, a series of swellings may form from the position of the old leaf axils as is shown in Figure 3 (D).

The lignotubers seem to be modified underground stem structures arising from the accessory meristems in the leaf

axils. Epicormic bud strands multiply in them in profusion.

If the seedling of a lignotuberous species becomes established in a difficult situation, the lignotuber may play a very important part in assisting the new individual to make a tree. The aerial portion of the young plant may be destroyed by fire, drought or animals, but the buds and reserve foods in the lignotuber permit it to shoot again when conditions are favourable. The second shoot is usually stronger than the first, and in turn it strengthens the reserves in the lignotuber and roots. The new shoot itself may be destroyed, and the process of production and destruction of new shoots and the increase in the reserves in the lignotuber and roots be repeated. Each new shoot is usually stronger than the last until finally a shoot is produced which is able to make a permanent aerial stem. In Figure 3 (C) three separate shoot developments may be observed. The oldest, marked 4, was destroyed by fire. The next, marked 3, probably died because of insect attack, The new shoots might have succeeded in making a tree.

Thanks to their partial underground habit lignotubers are not destroyed by bush fires. The fact that they are formed has probably been responsible for the wide range over which many species have survived. They are most prominent in difficult localities. In the case of the mallee they become large underground structures—the so-called "mallee roots". They are the most important factor of all in determining the nature of eucalypt regeneration.

The great majority of eucalypt species develop lignotubers, but a few do not, including *E. regnans* (Mountain Ash), *E. fastigata* (Brown Barrel), *E. gigantea* (Alpine Ash), *E. pilularis* (Black-butt), *E. grandis* (Flooded Gum), *E. diversicolor* (Karri), *E. camaldulensis* (River Red Gum) and *E. astringens* (Brown Mallet). In most cases, but not always, the species which do not develop lignotubers are typical of moist localities.

The species which do not form lignotubers develop carrotty-like swellings near the junction of root and shoot (Fig. 3 (E); *E. grandis*). These swellings also serve as a storage of food materials. The normal epicormic bud strands are present, but they do not proliferate as they do in the lignotubers. If the upper parts of the shoots are destroyed by other agencies than fire, the reserves in the swellings assist new shoots to form. However, the root swellings are sensitive to fire, and the species making them are not usually as persistent as the lignotuberous species.

THE DEVELOPMENT OF EUCALYPT REGENERATION

a. Seedfall, germination and early establishment

The seed of most eucalypts is very small, the number per pound being in the order of hundreds of thousands. The seed is produced in capsules varying in size from less than one-tenth of an inch to more than an inch in diameter. The larger ripe capsules may be found singly on the stems but the smaller ones are usually in inflorescences of three or more.

During very hot dry weather or after bush fires, ripe capsules may open on the tree and shed their seed. In this case the small seeds may fall to the ground under the tree, or be blown to a distance of two, three or sometimes more chains from the tree. The distance of dispersal of free seed depends upon the height of the tree, the wind, and whether there is forest or open country on the leeward side of the tree. Forest obstructs dispersal of seed.

In very many cases the ripe capsules of the eucalypts do not open on the tree. In some of these cases the capsules may remain on the tree full of seed for several years, but usually they are shed, rarely

singly, more often by individual inflorescences, but most frequently by branchlets carrying several inflorescences. These branchlets are usually dry and without leaves. In such instances they drop under or fairly close to the parent tree. In storms, however, green leafy branchlets bearing capsules containing fertile seed may be torn from a tree and blown hundreds of yards in open country and a surprising distance through forest. This is one way that progeny from an individual tree can be relatively widely dispersed.

In most localities eucalypt seed is almost sure to germinate within a year of falling from the capsules. The writer has not found evidence of prolonged dormancy. The newly germinated seedling is very small, and it is sensitive to flooding, drought, and fungal or insect attack. Even in favourable times the great majority of the seedlings die before they have had a chance to penetrate the mineral soil. Newly germinated seedlings may be found in tens of thousands in places where relatively few become established.

The way the seed is shed from the tree, and the depth to which soil may be washed over it by the rains, has an effect on the likelihood of a germinated seedling becoming established. Interesting information on these questions is given in a paper by Free (1951). Seed shed from capsules opening on a tree is dispersed over the ground by individual seeds. Seeds shed from capsules which fall from a tree and open on the ground may be grouped in little heaps. Free covered single seeds and heaped seeds with different depths of soil, and found that the germinating seedlings could emerge from surprising depths in both cases. Single seedlings pushed through 3/10 inch soil in the case of all species tried and through half an inch in the case of *E. pilularis* and *E. globulus*, which species have fairly large seed. Germinating heaps of seed were able to break through half an inch of soil in the case of all species tried, through one inch in the case of several species, while in one test a heap of seedlings of *E. globulus* broke through one and a half inches of soil. The seedlings which germinated at depth were less affected by temporary dry conditions than seedlings germinating near the surface. Free concluded that a covering of 0.2 to 0.3 inches gave best establishment. It is likely that accidental covering of the seeds frequently decides the individuals which have a chance to become established.

If a young eucalypt remains alive long enough to form a lignotuber, it is not easily destroyed.

b. Growth from seedling to sapling

If a eucalypt seedling germinates in a favourable locality in good growing weather, *and if leaf-eating insects are not present,* it will make rapid growth to sapling or tree size because of the expansion of a sequence of naked buds. Unfortunately this happens on all too few occasions in Australia. It may occur for a while when "wheatfield" regeneration of species like *E. regnans* or *E. grandis* provides an abundance of young trees in a locality where the fierce fire that causes the regeneration also reduces the insect population. However, even such rapid growers as the species mentioned do not push ahead as fast as they could in the absence of insects.

The most vigorous eucalypts of the best forest areas of Australia, such as *E. regnans, E. gigantea, E. fastigata, E. diversicolor, E. pilularis, E. grandis, E. resinifera* (in Queensland, not in N.S.W.) and *E. cloeziana,* pass from seedling to sapling stage without much check in spite of insect attack. However, over the greater part of the wide range of eucalypt country in Australia, it is more usual for a young eucalypt seedling to spend a few years in an apparently suppressed state, sending up a few small

shoots each year from the lignotuber as is shown in Figure 3 (C). The shoots may be cut back by insects, cattle, drought or fire, but the small plant shoots again when conditions are favourable. Each new shoot tends to be a little stronger than its predecessor, because there are more reserves in the lignotuber or root seedling, and because the root system is gradually getting a better grip on the soil. This process of strengthening the root system and lignotuber may go on for many years. Finally the time may arrive when deliberate treatment of the forest, or some accident, destroys larger trees in the vicinity and permits the "new" plant to grow to a sapling and then a tree. This final release from suppression can happen very quickly, and a sapling may be formed from the strengthened lignotuber in very few years. This fact tends to create the impression that the "new" trees which appear quickly after treatment in the forest and grazing land of Australia are recent seedlings. In most cases they are not recent seedlings; it is the reserves in the lignotuber and the stronger root system which allow the shoot to get ahead of its competitors. It is against commonsense to imagine that the one year old plant shown in Figure 3 (A) could compete successfully against the much stronger plant shown in Figure 3 (C). If leaf-eating insects could be countered, shoots from all plants would grow more rapidly, but the shoots from the larger lignotuber would still gain an initial advantage and maintain it in most cases. The smaller lignotubers do not necessarily die; they are more likely to remain in an apparently suppressed state, gradually strengthening their root systems, and awaiting their chance.

c. Lignotubers in forest areas

Lignotubers as large and larger than that shown in Figure 3 (C) may be found in great numbers in most of the eucalypt forests and savannah woodlands of Australia. When the forests are treated for regeneration, shoots from the lignotubers are likely to take early command of the site rather than seedlings germinating after treatment. In the best eucalypt forest seedlings of very vigorous species such as *E. regnans*, *E. pilularis* or *E. grandis* are likely to push ahead of lignotuberous shoots from slower growing associates. However, even in a forest containing *E. pilularis*, lignotubers from other species may be so common that they tend to dictate the nature of the next crop.

The lignotuber is a blessing, but a mixed blessing, to the Australian forester. On the credit side, the lignotubers accumulate for decades, and the forester is likely to get good regeneration after treatment, even in years quite unfavourable for the establishment of seedlings. On the debit side, all the more tolerant eucalypts develop persistent lignotubers, and they are not always the desirable species.

It can be an expensive matter to change the composition of a crop once unwanted lignotuberous regeneration has taken control. If the shoots from the lignotubers are cut back they return with surprising vigour. It may be necessary to grub them out.

In a poor forest area it may take many years for lignotubers to reach the point where they can produce shoots vigorous enough to take a place among the larger stems. In a study lasting 20 years the writer found that nearly all the yield of a eucalypt coppice forest came from shoots from old stumps or large lignotubers present when the original stand was felled (Jacobs, 1950). Younger lignotubers appeared in the forest during the study period, but they did not contribute to volume increment. At a later date some of them will provide strong shoots which will make the future forest.

There appears to be no reason why shoots from lignotubers should be avoided in forestry work if they are of a desired species. The writer has been unable to find evidence to date which would indicate that the shoots would not make commercial trees. The shoots are more vigorous and straighter than shoots from true seedlings.

d. Lignotubers in Pasture Lands

In summer rainfall regions lignotubers may attain weed proportions in country partly cleared for grazing. It is important that the nature of this regrowth should be understood.

In the absence of human action eucalypt trees are the most vigorous form of vegetation in many regions of summer rainfall in northern Australia. It is unusual if some seedlings are not established each wet season. These seedlings form lignotubers and strengthen them and their root systems each year. Thus, in partly cleared country a complete range of lignotuberous regeneration is established. There are some large individuals with enough reserves to send up vigorous shoots as soon as neighbouring trees are felled or ring-barked. Smaller ones await their turn, and a succession of crops is likely unless all trees and lignotubers are done away with, or until pasture management reaches a point where a combination of good pasture and grazing keeps the shoots from the lignotubers in a state of continued suppression. Forestry experience during recent years suggests that if fires and cattle are kept out, eucalypts will re-colonise pasture lands within a few years in the summer rainfall regions.

Eucalypt regeneration is not such a pest in grazing land in the regions of winter fainfall because seedlings may become established in particularly wet years only. However, once there the regeneration behaves in much the same way as in the summer rainfall country.

DO ROOT SUCKERS AND ADVENTITIOUS BUDS DEVELOP ON EUCALYPTS?

The position and number of shoots arising from lignotubers under and near eucalypt trees sometimes gives the impression that the shoots are arising from root suckers. This is particularly the case in regions of summer rainfall. Transfer of arsenical poison from tree to regrowth in the case of Moreton Bay Ash (*E. tesselaris*) has made it look as though the trees were suckering. However, on excavation, it was found that the shoots came from lignotubers. The transference of arsenical poisoning may have been caused by root fusion. The group to which Moreton Bay Ash belongs frequently produces weird shapes by the fusion of its branches. Fusion of roots is likely. The writer has not found eucalypt shoots arising from true root structures.

Roots may be produced from stem structures, including lignotubers. Several species layer under very wet conditions. *E. camaldulensis* puts out a type of aerial root from the lower part of the stem in some wet areas. Cuttings have been struck by experienced workers (Fielding, 1948).

The writer has never found a leafy shoot arising from a true adventitious bud of any kind in *Eucalyptus*. In spite of its remarkable ability to renew its leaves under the most adverse conditions, it appears that the genus does not make use of the adventitious bud. All bud producing tissue may be traced back to leaf axils which were formed at one stage or other in the life of the tree.

Acknowledgments

Thanks are extended to Dr. J. Griffiths Davies and Mr. T. B. Paltridge of the

Division of Plant Industry, C.S.I.R.O., for an opportunity to make a most interesting examination of the nature of eucalypt regeneration in summer rainfall pastures, and for their encouragement in the preparation of this paper.

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(*Received for publication August* 3, 1951.)

THE USES AND LIMITATIONS OF ARTIFICIAL INSEMINATION IN DAIRY CATTLE—

WITH SPECIAL REFERENCE TO AUSTRALIAN CONDITIONS

By D. S. WISHART

During the past fifteen years the use of artificial insemination (A.I.) in dairy cattle has increased considerably in many overseas countries, some having as many as 70 per cent. (Denmark) and 50 per cent. (Sweden) of all cows under regular insemination services. The fact that these services operate on such a scale, and have produced several generations of sound stock, should convince those sceptics who prophesied deterioration of constitution and failure to reproduce on the part of the artificially-bred animal. Moreover, it is apparent that the current technique of A.I. is producing successful results in terms of cows in calf, though its effect in improving herd production is not so easy to determine.

These results in other countries suggest that we, in Australia, should carefully consider the potentialities of A.I. under our own conditions. With this in mind, it is first necessary to take into account the limits of the scope afforded by present techniques.

The technical scope of artificial insemination

The collection of semen is not a difficult procedure, and the technique can be applied to most bulls. Bulls from which a regular supply of semen is to be collected are trained to become accustomed to a definite routine, and are used only for collection of semen during the season, as they may lose interest if natural service is permitted. In general, the difficulty of training increases with the age of the bull.

The average ejaculate of 4 ml. may be diluted with egg-yolk-citrate diluent to yield sufficient diluted semen to inseminate up to 400 cows. Higher dilutions, though possible, have limited practical use, as the number of cows actually inseminated from each bull is determined by the potential coverage of cows, i.e., by the organization of the service, rather than by the number of cow "doses" of semen available. The diluted semen, when stored at household refrigerator temperature, will generally remain suitable for use for four days.

The handling and examination of semen in the laboratory require special care and training. There is nothing very complicated about these things, but it is obvious that imperfect sterilization of equipment, or contamination of the supply of semen, can very easily lead to poor results in the field.

Although four days should be regarded as the average limit for successful storage of diluted semen, it is worth recording that, in 1946, five calves were dropped in Victoria to inseminations with semen from an American Jersey bull, the semen in this case being seven days in transit. Such results can only be achieved under ideal conditions, but nevertheless they indicate the possibilities of long-distance A.I.

Turning to the insemination of the cow, this may be performed not only during the period of heat, but also during the following twelve hours, as Nature, in her wisdom, arranged for the cow to shed the ovum from her ovary some hours after the end of the heat period. This has a

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practical significance, as it allows a daily insemination service to operate satisfactorily. The technique used in inseminating the cow is that of depositing the semen directly into the uterus; although this requires trained operators, its use is considered justified because it has been found to be about 15 per cent. more efficient than other more simple methods.

Results of artificial insemination

The organizers of A.I. services must have a fair idea how many inseminations will be required per cow in the unit, to ensure that the demand can be met. It is also necessary for the owners of the cows to be informed as to the type of results they can expect, because too many farmers believe that their cows are almost certain to hold to the first insemination. They are surprised to learn that an average of only 50-60 per cent. of healthy cows will conceive to the first insemination, a further 25 per cent. to the second, and 10 per cent. more to the third; in healthy herds, 90-95 per cent. of cows should be in calf after the third round, and an average of 1.7-2.0 inseminations per cow in calf can be expected. These results are slightly better than those obtained by natural mating with the average herd bull, though obviously some herds will fall above, and some below the average, as will also be the case with A.I.

Where breeding difficulties have been experienced in a herd under natural mating, the owner must be told that he can expect the same difficulties to occur with A.I. On this point, A.I. may be regarded merely as a means of carrying the semen from the bull to the cow, so that conditions preventing conception in the cow remain essentially the same in each case. However, infertility on the male side is avoided by A.I., as all semen is examined before use to ensure that only fertile semen is used.

Organization of A.I. services

Most A.I. services operate on a self-contained basis, the headquarters of the unit, with its office, laboratory, and bulls being located in the centre of the area covered by its member herds. Calls are received each morning, and the technician then makes his daily round of inseminations. The technician is also responsible for the routine of the centre itself, including the collection, handling and examination of semen, cleaning and sterilization of apparatus, management of the bulls, and insemination records—a range of duties in which he will require one or more assistants, depending on the size of the unit.

To keep travelling costs and time within working limits, it is necessary to restrict membership to herds within ten miles of the centre. Where inseminations are spread over the whole year, as in whole milk districts, one technician can cope with up to about 1,500 cows; in seasonal butter-fat districts, where matings are mostly carried out in a limited season, a membership of only 1,000 cows will require two technicians to deal with the large number of inseminations required each day during the peak of the breeding season. In seasonal districts, the question of continuity of employment for the technician arises, as the service may only be required for several months of the year.

The unit will require at least two bulls of each breed to be used, and it is usual for a third bull to be held in reserve. The supply of semen will be sufficient for several thousand cows, so that if the demand is great, it may be met by engaging additional technicians. To cover a wider area, sub-units may be established at a distance from the parent centre, from which regular supplies of semen will be obtained.

This latter system has been expanded, in U.S.A., to the stage at which one parent centre maintains about 110 bulls and supplies semen to 120 sub-units located up to 200 miles away. Fewer bulls are required, and this reduces the bull cost per cow; but the local unit still has to meet all other running expenses, and the overhead expenses of the parent centre are

relatively high, so that the cost per cow is not greatly reduced.

Bulls for artificial insemination

Ideally only proven bulls would be used in A.I. services, but in practice no country can obtain sufficient bulls for the purpose. Most units use the proven bulls they have, to inseminate as many cows as possible, and the remaining cows are inseminated with semen from young bulls which, although they have high production "backing" in their pedigrees nevertheless remain to be proved. It should be noted that A.I. enables a young bull to be proved—one way or the other—at a slightly younger age than by natural mating, and also more accurately because more daughters can be bred. Thus a number of young bulls can be given limited use in a unit for one season, and then leased out until such time as their daughters' production records are available to indicate which bulls qualify for further use by A.I. as proven sires; in Britain, certain units are now used exclusively for the proving of young bulls in this manner.

Costs of A.I. services

Two bulls of one breed, and the necessary equipment, represent the minimum capital cost of establishing a self-contained unit, assuming that a suitable room can be found for a laboratory. Equipment will cost about £300, and two proven bulls will cost at least £700, so that a minimum of £1,000 capital must be raised before operations can commence. Operating costs, including the technician's salary and transport costs, will amount to a minimum of £1,500 per annum.

For a unit of 1,000 cows, these figures represent a capital requirement equivalent to £1 per head, and an annual breeding fee of 30/- per cow, which usually covers three inseminations if required. These figures must be regarded as an absolute minimum. They assume a certain degree of improvization of existing facilities, but it is essential to realise that there is a limit beyond which improvization impairs efficiency and becomes false economy. Inefficiency inevitably leads to poor results —costs are increased as more visits per cow must be made; when members want their cows in calf quickly they become dissatisfied, their herds are withdrawn from the service and the unit loses income in proportion to the effect.

With A.I. services, the cost *per herd* obviously increases with the size of the herd. In overseas countries, herds in A.I. services are small—only eight to ten cows —so that the cost to the owner is less than that of maintaining his own bull, which is a sound reason for the popularity of A.I. overseas, irrespective of the merit of the bulls used. In Australia, where herds in the dairying districts average 40 or more cows, the situation is reversed, and A.I. costs more than natural mating. Theoretically the owner can replace his bull with an extra producing cow, and thus partly offset the extra cost of A.I.; this happens in small herds, where all female stock are inseminated, but in larger herds a bull will still be kept for the heifers—which run at a distance from the shed and are not under close observation—and also for the late-calving and difficult-breeding cows.

Improvement in herd production

The great advantage of A.I. lies in the widespread use which may be made of proven sires, with the almost certain guarantee that they will leave good stock. It is difficult to assess just how much improvement in herd production may be expected from the use of such bulls, as this depends on (i) the genetic merit of the bulls, (ii) the present average level of production in the herds, and (iii) whether breeding or feeding is the limiting factor in the *actual* production of these herds.

In New Zealand, where the best available Merit (proven) sires have been used by A.I. on a small group of commercial herds, the daughters' corrected averages are 24 lbs. of butter fat more than the 311 lbs. average of mature cows in the same herds. In Britain, where some 15

per cent. of all cows are being inseminated, and the requirement for numbers therefore necessitates a lower average standard for bulls, little if any improvement in herd production is now being made. It has been observed that owners tend to favour their artificially-bred cattle with extra feed, in expectation of high production; for this reason any increase in production may not be entirely due to A.I.

In Australia, those herds in which feeding is not the limiting factor could probably expect some improvement in production in the first generation from proven sires, and this improvement would be greatest in the lower-producing herds. As with any system of breeding, further gains would become more difficult to achieve as the level of production increased.

The Outlook on A.I. in Australian commercial herds

As the average dairy farmer must pay more for A.I. than his bull costs him at present, it is apparent that only the guarantee of improved production from the use of proven bulls can justify the extra cost—and where are the bulls?

Australia is no exception in the shortage of proven sires, and most of the few known proven sires cannot be bought from their owners. More extensive use of herd testing and sire surveys will locate more proven bulls, but the number available and suitable for A.I. is never likely to be sufficient for insemination services on a large scale. New Zealand herd recording figures, which cover herds totalling about 400,000 cows, show that 10 per cent. of bulls are herd improvers—a relatively large number of bulls; but it is significant that deaths, owner's refusal to sell, health and fertility tests, breed type and production index reduce the number of bulls actually obtained for A.I. in New Zealand to two or three each year.

With regard to the training of technicians, it can be assumed that the necessary course would be provided by the appropriate state department of agriculture in response to the demand, as has already been done in Victoria.

Assuming that suitable bulls could be acquired, A.I. services could then be established in districts in which, from herds within a ten-miles radius, sufficient breeding fees were guaranteed to meet running expenses and the necessary capital raised. As a minimum of about 1,000 cows is necessary, A.I. services would automatically be restricted to districts in which the cow population is relatively high. On this point, it is worth noting that two Victorian farmers' co-operative units, in districts where enthusiasm appeared to be high, were able to enrol only one herd in every five, even when proven bulls were to be used at 30/- per cow.

While cow inseminations would necessarily be organized on a local unit basis, economy of bulls would probably favour the establishment of bull centres from which semen would be distributed. The decision between bull centres in each dairying district or one to supply a whole state, would depend largely on the demand and transport facilities.

Actual experience of A.I. in commercial herds has been gained in Victoria, where farmers' co-operative units have been established, and later closed, at Timboon and Tatura. Two main reasons—inefficiency, resulting from improvization due to lack of capital, and seasonal infertility in the districts—combined to produce poor results in the field; the confidence of members fell, herds were withdrawn, and each unit closed because its income from breeding fees was insufficient to meet expenses, and all possible sources of capital had been exhausted.

The experiences of these units, and also those of the pilot units operated by the State Departments of Agriculture of Victoria (State Research Farm, Werribee) and New South Wales (Veterinary Research Station, Glenfield), have shown that many practical factors can assume significant proportions. Some of these, such as the loss of precious time by the technician in having to walk from the

road to the bails when farm "drives" are impassable, can be minimised or remedied. Others, for instance the refusal of bulls to work, or the illness of the technician, are problems which are not so readily solved, and provision for such emergencies must be made.

The dairy farmer will find that, without his bull, he will not be so certain whether a cow is in season, or which ones if a number are concerned, and he may also object to holding them in the yards for hours to await the arrival of the technician. Although he may not realise it, he will develop a critical awareness of his herd breeding record, probably set out for the first time in a manner which shows at a glance—as all such records should—when and how often each cow has been inseminated. To avoid disappointments, all the facts relating to the operation of the service and the results expected must be carefully explained to the potential member before he enrols his herd.

The uses of A.I. in stud herds

The ultimate aim of dairy cattle breeding is to improve the producing ability of the average cow in the commercial herds. It is apparent that, at present, there are far too few proven bulls available to cover more than a small fraction of the commercial herds, even by A.I. Under these circumstances, it seems a logical step to use these proven bulls **not** to improve production in a few commercial herds, but to use them as widely as possible, by A.I., to breed the greatest possible number of their sons. Thus the genetic merit of the best bulls in the country could be distributed widely through the studs and improve the calibre of the stud bulls available to the commercial herds.

To operate such a scheme would not be simple, but it is not impossible. It would probably be organized on a state basis, the bulls being held at a centre near the capital city for convenient access to transport services. Inseminations could be performed by technicians located in districts where studs were numerous; to assist more remote studs, the owner himself could be made familiar with the technique. Exchange of semen between state centres would be possible, and such a scheme could also make full use of semen imported from overseas proven sires.

Apart from the difficulties of organization, the establishment of such a scheme would depend largely on the interest of the breed societies and the breeders themselves. Many breeders are wary of A.I., if not opposed to it, fearing that their sales of bulls would be reduced; it seems certain that, if A.I. did develop in Australia, big premiums would be paid for the top bulls, and the financial effects on breeders would simply reflect their relative merits as breeders.

From the 1949-50 Annual Report of the Animal Research Division, Department of Agriculture, New Zealand, in which country dairying conditions are comparable with those of Australia, the following extract is relevant: "Summing up the results of A.I. work over the past seven years, it has become abundantly clear that the provision of a service to commercial dairy farmers on any adequate scale which would not only provide herd replacements of high quality but which also must succeed in getting the greater part of the herd in calf in the short mating period associated with our seasonal dairying is not only extremely difficult but hardly practicable with old proven bulls. On the other hand, since seasonal conception rates are not so critical on pedigree herds, and the supply of bulls is more nearly adequate, the extension of artificial insemination to pedigree herds on a national basis now seems both technically possible and practicable."

Although the average mating period of Australian herds is not as short as that aimed at in New Zealand, the conclusions which have been reached in that country are believed by the author to apply in general to Australian dairying conditions.

(*Received for publication November* 5, 1951.)

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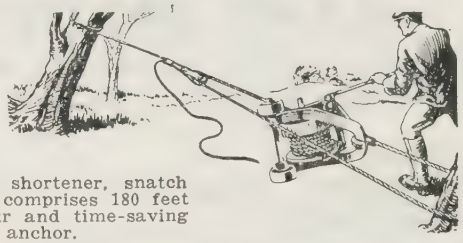

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THE INTERNATIONAL SOCIETY OF SOIL SCIENCE

By J. K. TAYLOR

International conferences on pedology and associated branches of soil study began in 1909 with an initial meeting at Budapest followed by the second at Stockholm in 1910, the third at Prague in 1922 and the fourth at Rome in 1924. At the Rome conference a new body, the International Society of Soil Science, was set up and rules of association formulated. Six commissions were organised for independent study of aspects of soil science and their activities were to be co-ordinated in five-year international congresses. The commissions were:—

I—Soil Physics.
II—Soil Chemistry.
III—Soil Bacteriology.
IV—Soil Fertility.
V—Soil Classification and Mapping.
VI—Soil in relation to Agricultural Technology.

The first International Congress of Soil Science was held at Washington, D.C., U.S.A., in 1927, the second at Leningrad in 1930, the third at Oxford in 1935. The fourth meeting was prevented by the outbreak of war.

International feeling against the aggressor countries in World War II caused the dissolution of the old organization. Attempts to set up a substitute were made at Moscow in 1945 when a number of international pedologists conferred, but fortunately the proposal to establish the organization embracing the United Nations only, received little support from national soil bodies. In 1947, a second conference with international representation met in the south of France and moves were begun culminating in a meeting in Paris later in the year, to hold the fourth International Congress of Soil Science at which a new society was to be formed. This Congress was held at Amsterdam in July-August, 1950, and a new International Society of Soil Science was founded with a new set of rules based very largely on the old constitution.

The Society is now operating with the support of all countries with interests in soil research except those in Central and Eastern Europe. The countries represented at Amsterdam and co-operating are—Argentina, Australia, Austria, Belgium, Canada, Chile, Denmark, Eire, Egypt, Finland, France, Germany, Great Britain, India, Israel, Iceland, Italy, Greece, Indonesia, Kenya East Africa, Mexico, Netherlands, New Zealand, Norway, Portugal, South Africa, Southern Rhodesia, Spain, Surinam, Sweden, Switzerland, Turkey, U.S.A., Yugoslavia.

Formation of the Society

A drafting committee was set up initially to prepare a set of rules and pilot them through the general meeting. The discussion in committee and the open meeting was vigorous and free and while all points of view naturally could not be reconciled agreement was reached.* Some of the delegates were not satisfied with the breadth of power given to the Executive up to the next Congress and it was agreed to on the basis that all arrangements were "between gentlemen" and in consequence they were expected to be democratic.

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*The author has a limited number of copies of the rules which are available to persons interested in the Society's proceedings.

The Society is truly international in that no distinction is made between scientists of any countries seeking admission either as corporate bodies or individuals. Powerful moves were made to have the Society an organization of affiliated national societies but this was defeated by the strong opposition of many countries, including European, which claimed no national group existed or truly represented them. Hence the membership became an individual one.

After long discussion the move to publish a journal, similar to the old *Soil Research,* was rejected and instead a bulletin is to be issued four times a year. This is designed to pass on information on research work being done, on individual members personally, the operations of institutions or national societies and for notices of the Society's business regarding Congresses, Commissions and Council proceedings. This is the return for the membership fee of $1 (U.S.) or equivalent.

Personnel of Administration

The Executive which takes office at the end of each Congress consists of a President, Vice-President, both of whom belong to the country in which the next Congress is to be held, Past-President, Secretary and Chairmen of the six Commissions. The Council consists of the Executive, one representative from each national society having at least 20 financial members of the International Society of Soil Science, and seven representatives of countries without national societies (two from Europe, two from Asia, one each from Africa, South America, Australia and New Zealand) provided again each represents 20 members.

The personnel of these bodies are:—

President:		
	Professor R. Tavernier.	Belgium.
Vice-President:		
	F. Jurion.	Belgium.
Past President:		
	Professor C. H. Edelman.	Netherlands.
Secretary:		
	W. R. Domingo.	Netherlands.

Chairmen—

Commission	I—Soil Physics—Professor S. Hènin, France
„	II—Soil Chemistry—Professor D. Deuel.
„	III—Soil Biology—Dr. S. Thornton, Great Britain.
„	IV—Soil Fertility — Dr. F. Steenbjerg, Denmark.
„	V—Soil Genesis—J. Thorp, U.S.A.
„	VI—Soil Technology—R. Hockensmith, U.S.A.

In addition six honorary members were elected from retired stalwarts of soil science—Sir E. J. Russel, Dr. D. J. Hissink, Dr. F. Demolon, Dr. W. P. Kelley, Dr. H. Winogradsky, Dr. S. A. Mitscherlich.

It may be mentioned that Dr. C. G. Stephens was elected as one of the Vice-Presidents of Commission V, and Mr. N. H. Taylor the representative on the Council for Australia-New Zealand.

Commissions and Sub-Commissions

The six commissions with chairmen have been listed above. It is competent for the Council to set up also either subcommissions or committees for special discussions. These may be more permanent in the former case. Two were proposed at the final conference meeting. The Mediterranean soil workers felt that the set of conditions operating in countries bordering that sea made it desirable for interchange of ideas and material, to achieve both better knowledge of the pedology and also a more informed approach to classification on a common basis. The idea was extended to include all countries with soils subject to what is usually termed a Mediterranean climate and as such Australia is concerned. A vigorous informal discussion was held at Amsterdam one evening with participants from Portugal, Spain, France, Italy, Egypt, Israel, Tunis, Algeria, Morocco, U.S.A. and Australia and from this a resolution was proposed at the final conference for the formation of a committee for study of the subject with Dr. D. L. Bramao, of Portugal, as convener. Up to date no further move has been

made but it was hoped correspondence might be initiated between countries on classification. This always depends on the enthusiasm of a few indivduals and it is possible the western Mediterranean workers may have exchanged views.

A second committee was discussed but not further proceeded with. This was on saline soils and Dr. L. A. Richards, of U.S.A., was the nominal convener. There was a very vigorous section in saline soils at the Amsterdam meeting and there is no doubt it is a subject with very wide interest in most countries of the world. Towards the end of last year Dr. Richards prepared a statement on this Committee to be issued with approval of the Executive in the first issue of the Society's Bulletin which has not yet come to hand.

Fifth International Congress

On the invitation of the Belgian Government the next meeting of the Congress was resolved for 1954 at Leopoldville in the Belgian Congo. The Belgians would not agree to any other centre in their territory though, for many, a European venue would have been more acceptable. At the 1950 Congress, one Section was devoted to discussion of tropical soils, a subject which seems to have caught the popular fancy in influential quarters. It is not quite clear what this term means—whether it concerns soils occurring in the tropical zone or soils subject to pedogenetic forces peculiar to high rainfall, high temperature, tropical climates. If the former there are many soils similar to those occurring in more temperate climates, if the latter then, while recognising their pedological interest, the economic advantage of understanding them is secondary to the significance of non-tropical soils. It is true the tropical zone has been much neglected by pedologists. However, the urge to discuss tropical soil problems was sufficient to place the next Congress in the Congo. It was thought by many that it should have been placed on a sectional basis rather than a full congress which might have met in some more accessible place in Africa.

Only one other function was announced, namely, a meeting of the Fourth Commission on Soil Fertility in Eire in 1952. Recently this meeting has been fixed for July in Dublin in combination with Commission II—Soil Chemistry.

Australian Membership

Australian membership in the old International Society was arranged through the British Society and a total of about 12 members was registered in 1939. The association lapsed during the war years but was raised again in the discussions on the new International Society from 1947 onward.

There are two alternatives which might be followed. Soil workers in Australia could join the British Society as full members (£1/1/- sterling) and receive the Journal of Soil Science and any other privileges of membership they were able to avail themselves of, such as information on meetings, conferences, and personalia. They would share a representative on the International Society Council. This is the course several Australian soil scientists have followed. The second proposal would be to set up an Australian Society of Soil Science similar to other national bodies. While this self-sufficiency might gratify some, such an organization would have obligations to members very difficult to meet. To fulfil their proper function all national bodies of permanence must offer members regular meetings or a journal as the binding link. In Australia any worthwhile journal for soil workers is impracticable and meetings could not be attended annually by most members due to distance and cost. Whether a definite section could be included in the Journal of the Australian Institute of Agricultural Science to meet the requirement has not been explored nor the basis of its maintenance. If an Australian society were organized it must give its members an

adequate and interesting return for their subscription and to hold their enthusiasm. These matters might be discussed in letters to this journal as all interested people are also members of the Australian Institute of Agricultural Science. Sooner or later a society will be formed and if later some other action needs to be taken now.

As indicated earlier, representation of Australia-New Zealand is allowed on the Council of the International Society of Soil Science provided there are 20 financial members in these countries. The subscription of the equivalent $1 U.S. is small and soil scientists in Australia are asked to send in their subscription to the Secretary-Treasurer—

International Society of Soil Science,
Royal Tropical Institute,
63 Mauritskade,
Amsterdam, The Netherlands.

It would be an easy thing for groups at different centres to send a block of subscriptions by mutual arrangement. Any subscriptions should be marked for the second year as since the Society was formed about 12 months ago it is presumable the dues will become payable for a financial year commencing not later than 1st January, 1952.

INOCULATION TECHNIQUES FOR STUDYING THE GENETICS OF VIRUS RESISTANCE IN PLANTS

By E. M. HUTTON and A. R. PEAK

Summary.

To test accurately the inherent resistance or susceptibility of hybrid seedlings to virus, it is necessary to consider such factors as maturity and vigour, environment, and effective virus dosage applied to the plants. In the absence of controlled environmental conditions, seedlings need to be grown at a time and tested at a growth stage which ensure that the physiology of susceptible phenotypes allows invasion by the virus and its uninterrupted multiplication. Standardisation of inoculation techniques so that a high and relatively constant virus dosage is applied to seedlings is necessary for an accurate assessment of resistant or susceptible phenotypes. The type and quantity of the abrasive used in inoculation is an important factor in keeping the points of virus entry at a maximum so that the best use is made of the active virus in the inoculum. Standardisation of the amount of abrasive applied can be achieved by adding a diatomaceous silica of low specific gravity to the inoculum or to the buffer or water used in making the inoculum.

Introduction

This paper is confined to a consideration of those viruses which can be transferred from one plant to another by mechanical means. Where these viruses have a vector, the use of an insect inoculation technique for testing the virus resistance of large numbers of seedlings from hybrid progenies is usually avoided because of the time and difficulties involved.

It is admitted that the insect has an advantage over mechanical inoculation, because with a nicety of technique unobtainable by laboratory methods it places the virus in a highly active form into the vascular system of plants. This advantage is only maintained where the virus dosage is kept at a high level by relatively large numbers of vectors and where young growing tissue ideal for virus multiplication is penetrated. If small numbers of vectors are used, or the vectors feed on old tissue, the determination of the inherent resistance or susceptibility of seedlings would have a low degree of accuracy. It is considered that if sufficient attention is given to the various factors involved in the hand inoculation of plants with viruses, techniques can be developed which are the equal of optimal insect inoculation.

Experience has shown that the hand inoculation techniques designed by plant pathologists for use in virus transmission studies need modification where the inheritance of virus resistance in hybrid progenies is the main consideration. This is due to the complex nature of virus resistance, which in common with other physiological characters is often polygenic in character and so subject to continuous variation. There are indications that spotted wilt resistance in the tomato *(Lycopersicon* species) may come into this category. With polyploids like the potato *(Solanum tuberosum* L.), continuous variation due to relatively large numbers of gene differences is also a feature, so that all types of reaction to virus from susceptibility through partial resistance to complete resistance are obtained in hybrid progenies. Additional complications in the instances mentioned are the effects of environmental factors and age and vigour of the plants on the resistance to virus. Completely susceptible pheno-

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types usually cause little difficulty, but where some of the genes needed for resistance are present, unsuitable inoculation techniques or lack of attention to environmental or other factors will often lead to classifying them as fully resistant. The geneticist and plant breeder, although interested in such partially resistant types as sources of genes, must be in a position to classify the seedlings in his progenies as either susceptible or completely resistant. In the field, partially resistant phenotypes lacking the full complement of resistant genes will give poor results in years which encourage a high degree of vector activity.

The foregoing considerations are particularly applicable where the less stable viruses like spotted wilt are involved, and where a relatively large gene complex determines resistance or susceptibility. Where the virus resistance of certain diploid species has been shown to depend on one or two genes, the evaluation of inherent resistance or susceptibility is not so difficult, but the need for carefully standardised hand inoculation techniques is still present. It is considered that in the development of suitable hand inoculation techniques for studying the genetics of virus resistance in plants the following factors need to be taken into consideration—amount and type of abrasive applied to the plant, source of virus, concentration of virus in the inoculum, stability of the virus during inoculation, method of application of the inoculum, condition of plants at the time of inoculation, and the environmental conditions during the pre-inoculation and post-inoculation periods. This paper reports experience and experiments on some of these aspects, most of the data being obtained with the relatively unstable spotted wilt virus.

Preparation of the inoculum and its transference to plants

In choosing the leaf tissue containing the virus for inoculation, young tissue in which symptoms have recently appeared is usually the best source of inoculum. If tissue is left until extensive necrosis has taken place, virus concentration will be greatly reduced and the material will be a poor source of virus. This is particularly so with a virus like spotted wilt where the virus concentration is likely to be markedly reduced with ageing and necrosis. In general the ideal inoculum is obtained by transferring the virus at regular intervals of 3 to 4 weeks to young host plants which are grown at temperatures from 70°F. to 80°F. The virus infected tissue is macerated in a mortar with water, or phosphate buffer at pH7, or in the case of spotted wilt, with phosphate buffer (pH7) to which sodium sulphite has been added (Best and Samuel, 1936). Tissue containing the more stable viruses like potato virus X and cucumber mosaic can be macerated with water in a Waring Blendor. To ensure a high level of infectivity in the inoculum, it should be replaced at intervals depending on the virus, and with spotted wilt every 20 minutes.

Where the plants are small the inoculum is most easily applied with the thumb and forefinger. With larger plants a spatula made by flattening $1\frac{1}{2}$ in. at the end of a glass rod 8 to 9 in. long and bending this end at 130° to the handle is an efficient implement for applying the inoculum evenly over the surface. Perspex bats with a handle 4 in. long and body 5 in. long and $4\frac{1}{2}$ in. wide are useful for supporting leaves being inoculated with the spatula. The application of an abrasive to leaves prior to inoculation or its incorporation into the inoculum is a necessary part of the procedure and will be dealt with in succeeding sections.

Types of diatomaceous silica compared with carborundum as abrasives for inoculation

Carborundum of high quality and of a grade between 400 and 500 mesh gives very consistent results as an abrasive with most viruses. For best results it needs to be dusted on the leaves prior to

inoculation. With dusting it is difficult to standardise the amount used in relation to any given quantity of inoculum. This is a disadvantage although experienced workers exercise some control over the amount of dust applied to leaves from a shaker. For transmission studies the hand duster described by Stubbs (1946) gives a relatively uniform dusting. A duster of this type is not suitable for testing the inherent resistance or susceptibility to virus of seeedlings in progenies containing all grades of resistance. This is because a light dusting of carborundum reduces the points of entry of the virus so that seedlings with a partial resistance are often able to localise the virus and appear completely resistant. A more liberal dusting from a shaker increases the number of points of virus entry and leads to a more accurate assessment of inherent resistance or susceptibility.

It is apparent that an abrasive which could be standardised in its use is desirable. In addition it is an advantage to have an easily accessible alternative abrasive to carborundum, as it is possible for high-grade carborundum to be in short supply from time to time. Diatomaceous silica as described by Kalmus and Kassanis (1945) appears to be a suitable alternative to carborundum, and due to its low specific gravity can be incorporated into the inoculum in definite proportions. Incorporation into the inoculum is also an advantage as it eliminates the process of dusting the plants prior to inoculation. Accordingly some readily available types of diatomaceous silica were tested in a preliminary experiment against carborundum dusting. For this experiment the stable potato virus X cultured in *Datura stramonium* L. was used, Globe Amaranth being the indicator (Wilkinson and Blodgett, 1948). *D. stramonium* leaf carrying virus X was macerated with pestle and mortar at the proportion of 1:50 by weight with water and four 100 ml. lots measured from it. A different type of diatomaceous silica was incorporated at the rate of 0.5 gm. in each of three lots of the inoculum so that the four treatments applied to the Globe Amaranth indicator were as shown in Table I. Two pairs of leaves on each of twelve plants were used in the experiment. The treatments were randomised and each treatment appeared once on every plant.

TABLE I

Carborundum dusting compared with the addition of diatomaceous silica abrasives to virus X inoculum by lesion number on Globe Amaranth

Abrasive	Mean No. Lesions* per leaf
Carborundum dusting	152.8
Kieselguhr (B.D.H.)	11.2
Standard Super-Cel	29.8
Hyflo Super-Cel	71.7

*All differences significant.

In this preliminary experiment it was obvious that diatomaceous silica abrasives varied considerably in efficiency for virus inoculation and that the best, Hyflo Super-Cel, would have to be used at a concentration of approximately 1 per cent. if it were to be as effective as carborundum dusting.

Another experiment was conducted using the spotted wilt virus cultured in tomato, and *Nicotiana glutinosa* L. as the indicator, carborundum dusting being the basis for comparison as before. Six 2.5 gm. samples were taken at random from a bulk lot of infected tomato leaf and placed in separate dishes and covered with 50 ml. of a phosphate buffer at pH 7 containing 0.2 per cent. sodium sulphite, the samples being macerated just before use because of the instability of the spotted wilt virus. Before maceration of three of the samples each had a different type of diatomaceous silica added to it at the rate of 1 per cent. A fourth sample had carborundum added to it in the same way. During inoculation of the *N. glutinosa* plants the inocula were kept stirred with the spatula. Fifteen young and vigorous *N. glutinosa* plants were used

and three leaves on each were inoculated, each half-leaf comprising a separate treatment. The treatments and results are shown in Table II.

TABLE II

Carborundum dusting compared with addition of diatomaceous silica abrasives and carborundum to spotted wilt inoculum by lesion number on N. glutinosa

Treatment	Mean No. lesions/ half leaf*
Carborundum dusting	171.6
Buffer only	33.7
Carborundum	109.5
Hyflo Super-Cel	180.1
Mollicel	129.9
Super-Cel	88.1

*All differences significant except that between carborundum dusting and Hyflo Super-Cel.

From Table II it is apparent that Hyflo Super-Cel is the most suitable of the types of diatomaceous silica tried for incorporation in the inoculum as it gives comparable results to carborundum dusting when added at the rate of 1 per cent. The Celite series of filter-aids come from quarries at Lompoc, California, and are classified according to the rates of liquid flow they allow during filtering. Hyflo Super-Cel is one of the coarser types and allows a high rate of liquid flow.

Effect of adding different concentrations of Hyflo Super-Cel to spotted wilt inoculum

An experiment similar to the previous one with *N. glutinosa* and the spotted wilt virus was done to compare carborundum dusting with concentrations in the inoculum of Hyflo Super-Cel ranging from 0.5 per cent. to 2.5 per cent. The treatments and the results are given in Table III.

In Table III lesion numbers are approximately one-third of those in Table II when similar treatments are compared. This is thought due to environmental conditions, the hot summer conditions in which the experiment of Table III was done restricting virus multiplication mainly by physiological changes in host and indicator plants. The results in Table III are in general agreement with those in Table II and show that a concentration of 1 per cent. Hyflo Super-Cel in the inoculum is as efficient as carborundum dusting and that the concentration can be increased to 1.5 per cent. with a corresponding increase in lesion number. Greater concentrations of Hyflo Super-Cel cause a marked falling off in lesion number, and it would be of interest to know the cause, as no visible injury occurred to the leaves of *N. glutinosa*. Perhaps the decrease could be attributed to adsorption of the virus.

TABLE III

Effect of varying the concentration of Hyflo Super-Cel in spotted wilt inoculum on the number of lesions in N. glutinosa

Treatment	Mean No. lesions/ half leaf
1. Carborundum dusting	59.8
2. 0.5% H.S.C.*	37.1
3. 1.0% H.S.C.	57.1
4. 1.5% H.S.C.	70.9
5. 2.0% H.S.C.	33.1
6. 2.5% H.S.C.	24.4

*In table H.S.C. = Hyflo Super-Cel. All results are significant except those between treatments 1 and 3 and between 2 and 5.

Incorporation of Hyflo Super-Cel into buffer for use over a period of a month

Bulk lots of water with 1 per cent. Hyflo Super-Cel in suspension were used successively from time to time over a period of several months for making virus X inoculum. This was used in testing the X-resistance of a large number of potato seedlings. It was thought that, if in the case of the relatively unstable spotted wilt virus a similar procedure could be adopted by including Hyflo Super-Cel in the buffer when it is made, a definite saving in time could be effected, especially where large numbers of tomato seedlings bred for resistance were being

tested. Accordingly 200 ml. of phosphate buffer at pH 7 and containing 0.2 per cent. sodium sulphite was made, and Hyflo Super-Cel at the rate of 1.5 per cent. was added. After making, this buffer was compared with carborundum dusting by the spotted wilt inoculation of three leaves on each of two *N. glutinosa* plants, the treatments being randomised appropriately on half leaves. This was repeated at ten-day intervals, the buffer being shaken each time before use and a pH reading taken. The results are given in Table IV.

TABLE IV

Carborundum dusting compared with the use of bulk buffer containing 1.5% Hyflo Super-Cel for spotted wilt inoculation of N. glutinosa at ten-day intervals

Treatment	Mean number of lesions at ten-day intervals			
	0	1	2	3
Carborundum dusting	53.5	28.5	37.0	40.2
Hyflo Super-Cel	46.5	22.0	43.0	45.7

Table IV shows that Hyflo Super-Cel can be added to bulk lots of phosphate buffer as an abrasive in place of carborundum dusting without any loss of efficiency in the inoculation of spotted wilt. No real differences in the pH of the buffer were observed over the period.

Virus dosage, plant maturity and environmental factors

The virus dosage entering the cells of plants is dependent on the concentration of active virus in the inoculum and the number of points of entry established during inoculation. With an inefficient abrasive the number of points of entry capable of supporting virus multiplication may be reduced and this would be similar in effect to the use of too little of an efficient abrasive. It has been clearly shown in the previous sections how the amount and type of abrasive can influence the number of lesions developed from inocula made from a common source. With respect to the amount of active virus in the inoculum, it has been assumed that increasing the concentration of virus infected leaf used in its preparation will increase this factor. That this is not necessarily so was indicated by an experiment with spotted wilt and *N. glutinosa* in which the number of lesions increased progressively when concentrations rang- from 1:40 to 1:10 were used but thereafter greater concentrations of infected leaf in the inoculum resulted in a decrease in lesion number. It seems that optimal virus dosage with spotted wilt may be achieved with a 1:10 inoculum provided the abrasive and other factors are standardised.

The maturity of the seedlings being tested is a very important aspect, and usually young vigorous plants give the best results as with spotted wilt in tomato, although with virus Y (Hutton, 1948) it was found that pre-flowering and post-flowering inoculations were required to assess the inherent resistance or susceptibility of potato seedlings. Even with what is usually regarded as a virus susceptible species, plant maturity can have a marked effect as was shown with virus X in *Nicotiana tabacum* L. It was shown that young plants were completely susceptible, while plants near flowering and at the flowering stage were resistant to systemic invasion by virus X.

With virus Y, plant vigour was an important factor in assessing the reaction of potato seedlings (Hutton, 1948) as weak plants would give a lethal necrosis, whereas vigorous duplicate material would give a localised one.

Bawden and Roberts (1947) have shown that reducing the light intensity under which plants are grown in the summer increases their susceptibility to virus infection. It has been shown that temperatures above certain levels can prevent virus development in a susceptible plant and make it appear resistant. It seems that within the range of species used hot summer conditions not only tend to re-

duce the virus concentration in host plants but tend to accelerate plant response so that seedlings with partial resistance appear fully resistant. For these reasons, the most accurate assessment of the resistance or susceptibiilty of seedlings is obtained during the cooler spring and autumn months with their lower light intensities. The variations which stem from changing environmental conditions are a strong argument in favour of controlled environments for such work.

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(*Received for publication, May* 29, 1951).

STUDIES OF GALVANIZED BURR—1. EFFECTIVENESS OF CHLORINATED PHENOXYACETIC ACID DERIVATIVES AS CONTROLLING AGENTS

By E. G. CUTHBERTSON

Summary

Investigations into the control of galvanized burr, *Bassia Birchii* F.v.M., with various chlorinated phenoxyacetic acid derivatives under two methods of application are described.

Marked reduction in burr numbers was achieved with triethanolamine and ethyl 2,4-dichlorophenoxyacetate and butoxy-ethanol 2,4,5-trichlorophenoxyacetate. Sodium salts of 2,4-D were not nearly so effective.

The toxicity of the triethanolamine salt of 2,4-D to galvanised burr is reduced when applied with low-volume equipment.

Galvanized Burr, *Bassia Birchii* F.v.M., a native of Queensland, has spread into the grazing areas of the north-west and central districts of New South Wales at an alarming rate. Large areas of hitherto valuable grazing lands are now virtually worthless. During the last decade its extension into the better class grazing and arable areas of the Central Western Slopes has been accelerated by the manpower shortages during the war years. A series of favourable growing seasons producing local floodings in the latter part of the period have made new infestations probable by distributing seed bearing portions of the plants over wide areas.

Hoeing out, stacking and burning—the present control method—is not entirely satisfactory. Seedling plants, which carry viable seed when only 1 or 2 inches high, are often missed, while insufficient care in burning results in the establishment of numerous seedlings around the site of the fire. High labour costs and the unavailability of labour are hampering eradication programmes.

Chlorinated phenoxyacetic acid derivatives have successfully controlled other woody and herbaceous weeds and could, therefore, provide an answer to the labour problem.

In the following account experiments carried out at Hermidale, New South Wales, using 2,4-dichlorophenoxyacetic acid and 2,4,5-trichlorophenoxyacetic acid derivatives as controlling agents are described and data are given on the value of two methods of application.

Experimental Procedure

Weed control programmes in the western districts of New South Wales using chemicals are limited by the availability of suitable water. Low-pressure, low-volume methods of application have made possible large-scale control programmes. Should there be a shortage of suitable water, kerosene and dieselene can be substituted for water as dispersal agents.

Plots were sprayed through a boom mounted on the back of a truck. Both high-pressure, high-volume and low-pressure, low-volume methods of application were used. Under high volume conditions the sprays were applied as dilute solutions at a rate of 100 gallons per acre; for low-volume applications sprays were applied as concentrated solutions at a rate of 3 gallons per acre. Pressures used were 150 lbs. per square inch and 25 lbs. per square inch respectively.

A portable high-power jetter, mounted on the truck, was used as the power source for the high-pressure spraying.

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The hose from the output side of the pump was coupled to the boom which was made from $\frac{3}{4}$ inch extra-heavy galvanized iron piping fitted at 1 foot intervals with 0.046 inch orifice "Dinoc" fantail nozzles. The low volume equipment consisted of a small petrol engine driving a $\frac{1}{2}$ inch rotary pump which delivered 60 gallons per hour. The finely atomised spray was obtained by special low-pressure, low-volume nozzles with 0.03 inch orifices.

Experiment 1

Areas with moderately thick, vigorously growing burr plants at all stages of maturity—from seedlings to plants 2 feet high—were sprayed with various 2,4-D and 2,4,5-T acid derivatives on February 6 and again on March 17, 1949.

Sodium 2-methyl-4-chlorophenoxyacetate (M.C.P.A.), the sodium and triethanolamine salts and the ethyl ester of 2,4-dichlorophenoxyacetic acid and the butoxy-ethanol ester of 2,4,5-trichlorophenoxyacetic acid were applied at three rates, *viz.*, 1 lb., 2 lb., and 4 lb. acid equivalent per acre under high volume conditions. At the same time M.C.P.A. and the ethyl ester of 2,4-D were applied at the same rates under low volume conditions.

Prior to spraying all plants lying within, or partly within, two marked areas on each plot were counted. Effectiveness of the various treatments was determined by expressing the number of plants killed at August 18, 1949, as a percentage of the original population.

Herbicidal action was slow although all plants, particularly those on the plots sprayed with the ester formulations, had received a severe setback by March 17, 1949. Foliage present at the time of the initial spraying was killed. However, new leaf growth was apparent in many instances. No distortion of the stems, typical of affected herbaceous plants, was noted.

By August 18, 1949, effective control had been obtained with the triethanolamine salt and the ethyl ester of 2,4-D, but the butoxy-ethanol ester of 2,4,5-T., M.C.P.A. and the sodium salt of 2,4-D, while severely damaging all plants, were not so effective as is shown in Table I. Where aerial parts were killed roots were completely rotted to a depth of at least 12 inches, but where even the slightest regrowth was apparent roots were apparently not affected.

TABLE I

. Percentage kill of Galvanized Burr Plants . obtained with various Derivatives of Chlorinated Phenoxyacetic Acid.

Treatments	Percentage kill		
	1 lb. active princ./ acre	2 lb. active princ./ acre	4 lb. active princ./ acre
M.C.P.A.	13.3	9.5	35.7
Sodium salt 2,4-D	0.0	50.0	50.0
Triethanolamine salt 2,4-D	100.0	66.0	100.0
Ethyl ester 2,4-D	100.0	94.5	100.0
Butoxy-ethanol ester of 2,4,5-T	33.0	75.0	100.0
Control—Not Sprayed	2.2		

The effectiveness of M.C.P.A. when applied by the low-volume method was markedly lower than when applied by the high-volume method. On the other hand method of application did not materially alter the effectiveness of the ester as is shown in Table II.

TABLE II

Percentage kill of Galvanized Burr obtained with M.C.P.A. and the Ethyl Ester of 2,4-D when applied with High-and Low-Volume Equipments.

Wedicide	Percentage kill	
	High volume	Low volume
M.C.P.A.	23.2	14.7
2,4-D ethyl ester	95.3	98.6

Experiment 2

A more detailed experiment, omitting the relatively ineffective sodium derivatives of 2,4-D and the more expensive butoxy-ethanol ester of 2,4,5-T, arose from the results of Experiment 1. Plots of thickly scattered galvanized burr at all

stages of maturity were sprayed with triethanolamine and ethyl 2,4-dichlorophenoxyacetate at rates of 1 lb. and 2 lbs. of the active principal per acre. Sprays were applied by both high and low-volume methods on November 14, 1949.

The five main treatments were arranged in randomised blocks with four replicates of each. A split plot technique was used to compare high- and low-volume methods of application.

Plants falling within, or partly within, strip quadrats on each half plot were counted. Circumstances beyond the control of the writer prevented a recount until June 7, 1950, when the number of surviving plants was determined. Percentage kill was obtained from these counts.

Analyses of variance using the inverse sine transformation were made on the percentage of plants killed under the different treatments. The means for each treatment are shown in Table III. The percentage of plants killed on the unsprayed plots was so low that the results from these plots were omitted from the analyses. All other treatments were obviously significantly different from the control.

TABLE III

Percentage kill of Galvanized Burr after spraying with Triethanolamine and Ethyl 2,4-Dichlorophenoxyacetate (Mean of 4 replicates).

Weedicide	Percentage kill	
	1 lb. active princ./ acre	2 lb. active princ./ acre
Triethanolamine salt 2,4-D	46.9	74.2
Ethyl ester 2,4-D	65.2	91.3
Control—Not Sprayed .	9.6	

Although appreciable differences occurred between the percentage kills obtained with the various sprays they just failed to reach significance at the 5 per cent. level (F – Test). However, application of the t – test showed a significant difference between the ethyl ester at 2 lb. per acre and the triethanolamine salt at 1 lb. per acre active principal. All other differences were non-significant.

Once again the interaction of pressure-volume with weedicide gave widely divergent results in the case of the non-ester formulation. In the case of the triethanolamine salt the difference between high-volume and low-volume applications reached statistical significance. No material difference occurred in the case of the ester. Results obtained are shown in Table IV.

TABLE IV

Effect of method of application on the Toxicity of Ethyl and Triethanolamine Phenoxyacetates to Galvanized Burr (Mean of 4 replicates)

Weedicide	Percentage kill	
	High volume	Low volume
2,4-D ethyl ester:		
1 lb. active princ./acre ..	60.1	70.2
2 lb. active princ./acre ..	92.0	90.6
2,4-D triethanolamine salt:		
1 lb. active princ./acre ..	78.5	16.7*
2 lb. active princ./acre ..	88.1	57.2*

*Indicates significant reduction at 5 per cent. level.

Discussion

In general, a measure of control of galvanized burr can be exercised with chlorinated phenoxyacetic acid compounds other than the sodium salts of the acid. A marked reduction in the number of living plants occurred with all other formulations. Chance of regrowth from plants with the aerial parts killed is slight as root growth in such cases was completely rotted to a depth of at least 12 inches.

The triethanolamine salt of 2,4-D and M.C.P.A. were more toxic to galvanized burr when applied at high pressure and high volume. This difference in toxicity associated with method of application was not exhibited by the ethyl ester of 2,4-D.

High-pressure, high-volume applications force the spray mixtures well into the interior of the shrubby burr plants.

The finely atomised spray from low-pressure, low-volume applications, settling slowly downwards, for all practical purposes affects only the external leaves and branches.

Marth and Mitchell (1949) and Mullinson and Hummer (1949) have shown that aliphatic esters of 2,4-D acid are volatile while the sodium and triethanolamine salts are non-volatile. Plants coming into contact with the vapours were seriously affected and the germination of seeds exposed to them reduced. It is, therefore, most likely that the reduced toxicity of the sodium and triethanolamine salts, under low-pressure, low-volume applications, is due, in a large measure, to their non-volatility.

Acknowledgments

The writer is indebted to Messrs. Lanes Pty. Ltd., for the loan of the "Lo-Vol" equipment and to Mr. F. C. McCleery for carrying out the statistical analyses. Thanks are also due to Messrs. A. C. Smart and T. Ewings on whose property the experiments were carried out, and to Messrs. R. G. Lincoln and R. Bourke for assistance in the field.

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(*Received for publication April* 3, 1951).

THE DETECTION OF NECROSIS IN LEAF ROLL INFECTED POTATO STEMS BY MEANS OF FLUORESCENCE MICROSCOPY

By G. P. KELENY

Summary

The distribution of the phloem necrosis along the entire length of stems of nine varieties of leaf roll infected potatoes was examined, using the phloroglucinol test and fluorochrome stains. The efficacy of the two staining techniques is compared, and the latter method, involving the use of fluorescence microscopy, is described.

Introduction

The presence of phloem necrosis in potato stems infected with leaf roll virus has long been recognised and utilised as a means of diagnosing the presence of the virus. A simple method of staining the necrotic phloem, using phloroglucinol and hydrochloric acid, was reported by Sheffield (1943), modified by Wilson (1948) and further improved by Hutton and Oldaker (1949). This technique, in its modified form is considered to be a fairly reliable and consistent method for the routine testing of potato stems for leaf roll infection. Considerable interest was therefore created when Bode (1947) claimed that a staining technique involving the use of fluorochrome stains and a fluorescence microscope, was more effective in the detection of the early stages of phloem necrosis, and consequently of leaf roll. All authorities agree that the anatomical changes brought about by virus infection take place before foliage symptoms become noticeable.

The present note seeks to report (a) experience gained in the use of the fluorescence technique (b) the result of experiments comparing the efficiency of the phloroglucinol and fluorescence tests and (c) the distribution of phloem necrosis in infected stems.

The other technique described by Bode (1947), namely, staining with diamant fuchsin, did not prove altogether satisfactory and will not be discussed here.

The fluorescence technique

The technique of fluorescence microscopy was described by Metcalf and Patton (1944). In the initial stages of the investigations the arrangements recommended by Hamly and Sheard (1947) were tried but great difficulty was experienced in obtaining satisfactory light from the carbon arc. Finally the equipment used was a special microscope lamp, equipped with a 250 watt mercury arc globe, an ultraviolet-transmitting filter of 4000Å, and a yellow ultraviolet-excluding filter fitted into the ocular of the microscope. The two filters were complementary and in the absence of a fluorescing substance in the path of ultraviolet rays, no visible light was noticeable in the ocular lens of the microscope. The lamp emitted a very strong and almost unwavering light, allowing satisfactory microscopic examination, even at high magnifications.

In staining sections of leaf roll infected potato stems Bode (1947) used both Rhodamine B and Coriphosphine at 1:20,000 in a sodium di-hydrogen phosphate buffer of pH 2.0, but in the investigation described below a 1:10,000 con-

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centration was used. Reasonably thin freehand sections of stems preserved in 50 per cent. alcohol were stained for approximately 2 minutes in each of the fluorochromes. The fluorescence of the necrotic phloem cells appeared to be more distinct when Rhodamine B was followed by Coriphosphine. Both stains affect similar tissues but the latter displaces the former in the xylem, turning it yellow, while the necrotic primary phloem cells remain pink or red. The healthy phloem cells remain unstained and blend into the yellow background created by the yellow ultra-violet-excluding filter. The general appearance of the necrotic symptoms in the phloem is similar to that revealed by the phloroglucinol test and described in detail by Sheffield (1943).

Examination of stems

Sheffield (1943) in her original description of the phloroglucinol technique stated that necrosis always commences near the base of the stem and recommended that six nodes of each stem should be examined in doubtful cases. Bode (1947) also considered that there was a lessening of intensity of necrosis from base to tip of the stem. The procedure adopted in the study reported here was to examine, by both phloroglucinol and fluorescence tests, adjoining sections from the first three nodes above ground and every second node thereafter, also from two nodes below ground. Thus, in obtaining data on the distribution of necrosis along the stem, a comparison was also made between the two staining techniques.

The material for these experiments was obtained from field plots from which plants exhibiting symptoms of secondary leaf roll were dug, and the stems stored in 50 per cent. alcohol pending examination. It comprised the following groups:

10 plants of Katahdin.

4 plants of Factor planted early in the season.

4 plants of Factor planted late in the season.

At least two stems of each plant were examined and a necrosis rating ranging from 0 to 5 given to each section examined. A typical result is illustrated in Table I.

The examination indicated a tendency for the maximum sympton development to occur not at ground level, but approximately at the 5th or 7th node. In addition the data confirmed the claim of Bode (1947) that the method of examination developed by him is superior to the phloroglucinol test as it seems to reveal a greater number of necrotic cells, at a greater intensity and at an earlier stage of development. It will be noticed from Table I that while no necrosis could be detected in the basal node by means of the phloroglucinol test, it was readily observed by using the other technique. This fact is of considerable practical importance in routine testing of potato stems. If the fluorescence technique is employed, an examination of the basal node will apparently indicate the presence or absence of the leaf roll virus infection, even if not in its greatest concentration, and thus obviate the necessity for sectioning six nodes as recommended previously.

Similar results were obtained using stems of the potato varieties Sebago 80, Manistee, Brownell, Cayuga, Potomac, Chippewa and Smooth Rural which exhibited leaf roll foliage symptoms in the field. An attempt was also made to compare the staining techniques on stems of tomato and *Datura stramonium*, infected with tomato big bud virus (virescence) and tobacco yellow dwarf virus. Although only severely diseased plants were sectioned, and in insufficient number for conclusive results, the preliminary observations appeared to justify further work.

There exists the possibility that the fluorescence technique may stain phloem elements altered by some means other

than virus degeneration and thus may not indicate true leaf roll infection in every instance. This possibility is suggested by the fact that in several stems of varieties other than Factor and Katahdin the fluorescence technique gave positive reaction whereas the phloroglucinol technique showed no trace of phloem necrosis anywhere in the stem. Due to changed circumstances, the writer has not been able to check this possibility or continue these investigations and it is for this reason that the observations are submitted for publication at this stage.

TABLE I

Comparison of phloem necrosis rating obtained by phloroglucinol and fluorescence methods on a stem of leafroll-infected Katahdin potato

Node	Phloroglucinol test		Fluorescence test	
	Remarks	Rating	Remarks	Rating
2nd below ground	Clear; free of necrosis	0	2 necrotic areas in external phloem	1
1st below ground	Clear; free of necrosis	0	10 necrotic areas in external phloem; internal phloem almost clear	1–2
Ground level	Clear; free of necrosis	0	Necrotic cells in 2 areas in external phloem; 1 necrotic area in internal phloem	1
1st above ground	Clear; free of necrosis	0	Numerous lesions in internal phloem	1–2
2nd above ground	Clear; free of necrosis	0	2 necrotic areas in external phloem	1
3rd above ground	Clear; free of necrosis	0	3 necrotic areas in external phloem	1
5th above ground	Clear; free of necrosis	0	5 necrotic areas in external phloem	1
7th above ground	4 necrotic areas in external phloem	1	Almost continuous necrosis in external phloem; 1 large area in internal phloem	3
9th above ground	Faint necrosis in external phloem	1–2	Almost continuous necrosis in external phloem	3
11th above ground	Faint necrosis in external phloem	1	Some severe necrotic areas in external phloem	1–2
13th above ground	Some faint necrosis in external phloem	1	Several severe necrotic areas in internal and external phloem	1–2

Acknowledgments

The author wishes to record his thanks to Dr. D. O. Norris of the Division of Plant Industry, C.S.I.R.O., Canberra, for providing the plant material, and for helpful advice throughout these investigations, also to Dr. M. F. Day of the Division of Entomology, C.S.I.R.O., for permission to use the fluorescence microscope lamp.

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(*Received for publication June* 16, 1950.)

FUSARIUM WILT OF TOMATO—THE EFFECT OF LEVEL OF NUTRITION ON DISEASE DEVELOPMENT

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Summary

Experiments were done in sand culture and soil to study the effect of nutrition on development of Fusarium wilt of tomato. Increasing the level of nutrition of the host, in sand culture, resulted in a decrease in the severity of the disease. There was no clear evidence that this effect was anything more than a delaying of death of the plants. In the soil used results were so inconsistent that it is considered that control of this disease by fertiliser treatment would not be practicable.

Introduction

The effect of nutrition of the tomato *(Lycopersicon esculentum* Mill.) on the course of development of Fusarium wilt caused by *Fusarium bulbigenum* var. *lycopersici* (Brushi) Wr. and R. has been investigated by several workers. Under the conditions of their experiments all have demonstrated a modification of the course of the disease. Fisher (1935) showed an increase in severity in variety Bonny Best with excesses of nitrogen and boron, and a decrease when they were deficient. Excess or deficiency of either magnesium or phosphorus decreased severity of disease in Bonny Best but increased it in the variety Marglobe. These results are at variance with those of Walker and Foster (1946) who found no difference in reaction between the two varieties Bonny Best and Master Marglobe, and showed that the effect of nutrition was of less importance than that of inherent resistance of the variety. Their work also demonstrated a decrease in severity of disease with increasing concentration of a balanced nutrient solution from 0.1 to 3 times normal strength. They also showed that the disease could be modified by unbalanced nutrition. An increase in severity resulted from high nitrogen or low potassium levels, and high levels of potassium decreased severity. Stoddard and Dimond (1948) found a decrease in severity with solutions which were both one-tenth and ten times the concentration of the normal solution concerned and concluded there is evidently an optimal nutritional level for infection of tomatoes and severity of the disease.

Fisher (1935) in an extension of his work from water culture to soil obtained greenhouse results which suggested that heavy applications of lime, together with a well-balanced fertiliser, may be of practical value in reducing the amount of infection.

Experiments reported in this paper were designed to determine whether the demonstrated effects of host nutrition on the development of the disease could be used as a basis for control of the disease by attention to fertiliser practice.

The criterion used for comparison of treatments was the percentage of the population killed at definite time periods after sowing. This criterion, however, does not give a true picture of the seriousness of the disease in the whole population. It was obvious that many of the plants not actually killed were so badly affected by the disease that they would not give an economic return.

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Soil Experiments

Since the primary object of this work was to investigate the possibility of using nutritional methods for practical control of the disease, the problem was first investigated in heavily infected soil.

Material and Methods

Plants were grown in a steam sterilized brown clay loam from Dickson Experiment Station, A.C.T., in 6-in. unglazed pots. Since this soil was known to be phosphate deficient (Mackay, 1948) all pots received a basic dressing of $NaH_2PO_4.H_2O$ at a rate equivalent to P_2O_5 contained in 1 cwt./acre of 22 per cent. superphosphate.

Inoculum was added to each pot by the incorporation of 500 gm. of heavily infected soil into the top 2 in. of soil immediately before sowing. Seed was sown directly in the inoculated soil and after germination, plants were thinned to one per pot. Fertiliser applications used were nitrogen as $NaNO_3$, potassium as K_2SO_4 both at the pot equivalent of 5 cwt./acre and phosphorus as $NaH_2PO_4.H_2O$ at the pot equivalent of P_2O_5 in 5 cwt./acre of 22 per cent. superphosphate. Lime was added as $Ca(OH)_2$ at the rate of 3 ton/acre. All chemicals used were of laboratory grade. Treatments were applied singly and in all combinations giving a total of 16 treatments, each of which was replicated 10 times. All treatments, with the exception of lime, were added as solutions after sowing. Lime was incorporated into the top 2 in. of soil before sowing. In all there were three soil experiments done in the greenhouse. These were sown in December, 1947, and June and August, 1948, and the susceptible variety Bonny Best was used throughout.

At the conclusion of all experiments any plants which had not shown symptoms indicative of well-advanced invasion were checked for effectiveness of invasion by plating to potato-dextrose agar. The results of all such tests were positive.

Results

With the soil used in this work results were so irregular that it was obvious that the effects of nutrition were not sufficiently marked to exercise a practical control of the disease. In each individual experiment there were marked differences between treatments but there was no consistency between results in any one treatment in the three experiments. For this reason, it was decided to use sand culture for further studies in order to determine the degree of control which could be obtained over this disease by attention to host nutrition.

Sand Culture Experiments

Material and Methods

A fine beach sand was used for sand culture experiments. Analysis of this sand was SiO_2 : 99.6 per cent., $Al_2O_3 + TiO_2$: 0.24 per cent., and traces of each of Fe_2O_3, CaO, MgO and organic matter. Surface applications of 50 ml. nutrient solution were made twice weekly. The solution designated No. 1 by Hoagland and Arnon (1938) was used in this work as the normal (N) concentration. The concentration of other solutions used has been given as fractions or multiples of the normal, and in all cases the concentration of trace elements has been varied in the same proportion as majors. The pH of all solutions was adjusted to 6.5.

The experiments were done in undrained enamel pots $7\frac{1}{2}$ in. in diameter and $6\frac{1}{2}$ in. deep. Additional water requirements were supplied as distilled water. Seeds were sown in the pots and after germination plants were thinned to five per pot; four equally spaced on the circumference and one in the centre. Nutrient applications were commenced seven days after sowing.

Plants were inoculated one month after sowing by the technique described by Mills and Hutton (1946). The fungus was grown on potato-dextrose agar for seven days prior to seeding of Tochi-

nai's solution. As in the experiments done in soil, any plants which did not develop advanced symptoms were checked for effectiveness of inoculation by plating on potato-dextrose agar. The results of all these tests were positive.

The details of the three sand culture experiments are summarised below.

Experiment 1: Sown December 29, 1948, and concluded four weeks after inoculation. Nutrient solutions of 0.5, 1.0, 2.0 and 3.0 normal concentrations were used. There were 16 replicates of each treatment.

Experiment 2: Sown April 26, 1949, and concluded six weeks after inoculation. Nutrient solutions of 0.1, 0.2, 0.5, 1.0, 2.0, 3.0 and 5.0 normal concentration were used. Results of the first experiment had been so consistent that a reduction in replications to 10 per treatment was possible. Plants treated with 5.0 normal nutrient solution were badly affected by damping off in which *Fusarium* was not concerned and were discarded.

Experiment 3: This was a repetition of Experiment 2 sown on July 27, 1949, and concluded seven weeks after inoculation. Previous to inoculation plants receiving 0.1 normal nutrient solution damped off so badly that they were discarded.

Results

The results of all sand culture experiments are presented in Table I, which shows the percentage of plants killed in each of seven nutrient solution concentrations at seven-day intervals. The percentages have been analysed using the inverse sine transformation, and minimum significant differences have been determined at the 5 per cent. level.

Considering these results as a whole it is apparent that, within the range used, as the level of nutrients is increased, the percentage of plants killed in a defined period decreases.

Consideration was given to the fitting of a family of curves to the data of these experiments. The plotting of time or the logarithm of time against the percentages converted to probits did not give linear relations. The most satisfactory type of expression was—

$$log.\ (per\ cent.\ survival) = a + bt$$

(where a and b are constants and t is the interval from inoculation); this relation holding over the range 5 per cent. to 95 per cent. survival. Lines were fitted by eye to the plotted points and the time to reach 25, 50 and 75 per cent. kill read off. These values are presented in Table II.

From these results it is clear that the effect of additional nutrients is to lengthen the interval before a defined percentage of plants succumb to the disease, but there is no clear evidence that the effect of added nutrients does anything other than postpone death even at the highest levels used in this work.

Discussion

The results reported in this paper demonstrate that the course of development of Fusarium wilt of tomatoes can be modified by changing the nutritional status of the host. With balanced nutrition the severity of the disease decreased as the concentration of the solution increased. The effect was, however, merely a delaying of time of death of the plant and could not be considered as a control of the disease in the practical sense. Furthermore, these effects were obtainable only with the degree of nutritional control possible in sand culture and could not be demonstrated in soil experiments.

The effects of changing nutritional status on host pathogen relationships demonstrated here in sand culture are similar to those reported by Walker and Foster (1946), but the differences between treatments are not so marked. These workers used a continuous drip method of nutrient application thus providing a greater total amount of nutrients than would be obtained here with surface applications, and subsequent dilution with watering. In the course of this work no

TABLE I

Percentage of plants killed by Fusarium wilt at each of seven nutrient levels in three sand culture experiments

	Days After Inoculation	Nutrient level													
		0.1N		0.2N		0.5N		N		2N		3N		5N	
		% killed	Transformed value	% killed	Transformed value	% killed	Transformed value	% killed	Transformed value	% killed	Transformed value	% killed	Transformed value	% killed	Transformed value
First Experiment	14					38.8	38.5	23.8	29.2	30.0	33.2	6.3	14.5		
	21					96.3	79.0	92.5	74.2	86.3	68.3	62.5	52.0		
	28					97.5	81.0	98.8	83.8	96.3	79.0	73.8	58.8		
	Least difference for significance at 5% between transformed values = 9.1.														
Second Experiment	14	28.0	31.9	36.2	37.2	24.0	29.3	2.0	8.1	2.0	8.1	4.5	12.2		
	21	96.0	78.5	97.9	80.2	92.0	73.6	90.0	71.6	84.0	66.4	50.0	45.0		
	28	98.0	81.9	97.9	80.2	96.0	78.5	96.0	78.5	94.0	75.8	84.1	66.5		
	35	98.0	81.9	97.9	80.2	96.0	78.5	100.0	90.0	94.0	75.8	88.6	69.9		
	42	98.0	81.9	97.9	80.2	98.0	81.9	100.0	90.0	94.0	75.8	93.2	75.3		
	Least difference for significance at 5% between transformed values = 11.5.														
Third Experiment	21			6.0	14.2	2.5	8.5	0.0	—	0.0	—	2.0	8.1	0.0	—
	28			32.0	34.4	2.5	8.5	2.0	8.1	14.0	22.0	10.0	18.4	4.3	12.0
	35			64.0	53.1	25.0	30.0	36.0	36.9	36.0	36.9	18.0	25.1	23.4	28.9
	42			72.0	58.0	62.5	52.0	62.0	51.9	48.0	43.9	26.0	30.7	31.9	33.9
	49			86.0	68.0	70.0	56.8	82.0	64.9	58.0	49.6	40.0	39.2	31.9	33.9
	Least difference for significance at 5% between transformed values = 11.5.														

TABLE II

Time, in days after inoculation, required to attain 25, 50 and 75 per cent. kill by Fusarium wilt at different nutrient levels in each of three sand culture experiments

Nutrient level	Days after inoculation								
	1st Experiment % kill			2nd Experiment % kill			3rd Experiment % kill		
	25	50	75	25	50	75	25	50	75
0.1N				13.7	14.5	16.0			
0.2N				13.7	15.0	17.3	25.7	32.3	43.7
0.5N	13.3	14.3	16.2	14.0	15.4	17.8	34.2	40.3	51.2
N	14.0	15.2	17.3	16.2	17.2	19.3	32.0	38.1	48.5
2N	13.8	15.6	18.6	16.6	17.7	19.8	32.0	43.8	
3N	16.2	19.5	25.3	17.8	20.4	25.3	39.3		
5N							40.7		

optimum nutritional level for infection of tomatoes, as found by Stoddard and Dimond (1948) was demonstrated.

The results obtained in soil, however, do not agree with those of Fisher (1935) whose work suggested that fertiliser practice may possibly be used as a practical control of the disease. Under greenhouse conditions, using a specific soil, it was impossible to obtain consistent results with any treatment used. It is considered that fertilizer treatment under field conditions would give even more variable results than in the greenhouse and would not be a practical means of control. The effect of added nutrients is merely to delay ultimate death due to the disease and in no way induces a high degree of resistance in a susceptible variety.

Acknowledgments

The author is indebted to the following members of the staff of Division of Plant Industry, C.S.I.R.O.—Miss M. Mills for providing the *Fusarium* isolate used, and Miss J. Buffinton for valuable technical assistance, and to Mr. G. A. McIntyre, Section of Mathematical Statistics, C.S.I.R.O., for the necessary analyses of results.

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(*Received for publication, April* 18, 1951.)

TECHNICAL NOTES

BROWN ROT OF STONE FRUITS

I. AN UNSUCCESSFUL ATTEMPT TO INCREASE PERCENTAGE INFECTION BY ARTIFICIAL INOCULATION

Variability in the incidence of brown rot of stone fruits in Canberra orchards was reported by Angell (1949). Also reported were attempts to increase the percentage of brown rot by increasing the amount of inoculum in an apricot tree in a home orchard (Angell, 1950).

The present note deals with another attempt to increase the percentage of disease on a branch of the same tree as was used a year previously. Cultures of *Sclerotinia fructicola* (Wint) Rehm, were placed last season above ripening fruit in the tree, the distribution of conidia from them being left to chance. This season suspensions of conidia were sprayed on to the fruit, and sporulating diseased fruit were also introduced from other sources.

On October 19, 1950, approximately 20 million conidia from 7 day old transfers of *S. fructicola* were suspended in a nutrient medium and sprayed on to a branch bearing about 300 fruit. The percentage germination of the conidia in nutrient solution in the laboratory was 99 per cent. in four hours. Rainy weather prevailed for two days previous to spraying with inoculum, and for a day afterwards. The temperature outdoors was 55°F. One week, two weeks and four weeks later, when weather conditions were again conducive to the retention of drops on the foliage and fruit, spraying with suspensions of conidia was repeated. The total number of conidia in the four suspensions was estimated at more than 500 million.

Because the dry weather conditions which prevailed after November 19 were not conducive to the retention of drops of suspensions for long enough to allow germination of conidia, spraying was discontinued. Instead, sporulating diseased fruit, collected from other trees, were placed in a shallow container and left among the fruit on the sprayed branch, ensuring a continuous supply of inoculum.

On November 23, three days after the last spraying with inoculum, infection of one green apricot on the sprayed branch was observed. Four other fruit, which were evidently infected somewhat earlier, were also observed on the same day on one unsprayed branch on the side of the tree opposite to the sprayed branch. All these infected fruit continued to sporulate for some weeks.

The ripening period was from December 17, 1950, to January 4, 1951. Counting of the diseased and healthy fruit on the sprayed branch and the unsprayed branches was continued until 900 were picked. On the sprayed branch 30 out of 264 were brown rotted, and on the unsprayed branch, 129 out of 637. The percentage of brown rot on the sprayed branch was then much lower than on the unsprayed branches, and it was obvious from subsequent observations that more fruit was becoming in-

fected on the unsprayed branches than on the sprayed branch.

Because of the generally accepted ideas concerning the relation of spore load to brown rot infection if climatic conditions are suitable, home orchardists cannot be expected to allow their trees to be used for such an experiment as the one just described. Replication is therefore impracticable until an experimental orchard is available. In the meantime the tentative conclusion from the results of this experiment is that under the conditions described, the heavy spore load is not the factor responsible for severe brown rot infection.

It was stated in an earlier paragraph that spraying was discontinued because weather conditions were not conducive to long retention of drops containing spore suspensions on foliage and fruit. Although such weather conditions persisted throughout December, the total rainfall for the month being 46 points, 20 of which fell on the 30th; the percentage of brown rot on the tree was 18. This percentage was much higher than in the wet December of 1947 when there was less than 1 per cent. infection on the same tree. It may also be added that total loss of fruit by brown rot was observed this season on two trees in other orchards and more than 80 per cent. loss on another tree.

These results indicate the need for study of the factors which modify the susceptibility of individual trees. Under Canberra conditions, susceptibility is probably induced by soil and moisture factors in the immediate environment of individual trees.

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(*Received for publication March* 13, 1951).

ERRATUM

In Volume 17, No. 3, September, 1951, an article by C. G. Stephens entitled "The present state of soil science" was published. On page 127 the large italicised "T" in Szymkiewicz's formula was intended to represent the Greek letter "tor".

RHYPARIDA DISCOPUNCTULATA ATTACK ON JUTE

During 1947 experimental plots of Ramie (*Boehmeria nivea*) grown in North Queensland were extensively attacked by the Chrysomelid beetle *Rhyparida discopunctulata* Lea. The beetles mainly attacked the petioles of the upper leaves near their junction with the blades. This resulted in the affected blades hanging in a vertical position and rendered the *Rhyparida* attack very obvious, although in most instances the damage was not great enough to cause economic losses.

Recently the same species of beetle has turned its attention to jute (*Corchorus sp.*) which is now being grown experimentally in North Queensland. Two species of jute, *C. olitorius* and *C. capsularis*, are being grown at the present time. *Rhyparida* has only attacked the former. In spite of the fact that the two jute species are growing in plots side by side not a single plant of *C. capsularis* is affected. On the other hand the damage to *C. olitorius* is severe. Girdling of the petioles of the upper leaves has occurred to a marked degree, with consequent death of the leaves. In most plants the beetles have also eaten portions of the terminal shoots resulting in the death of the growing points. In addition con-

Figure 1.
Jute (Corchorus olitorius) showing terminal shoots damaged by Rhyparida discopunctulata Lea.

siderable surface feeding on the capsules has taken place.

From an economic point of view the damage to *C. olitorius* would be serious, as the destruction of the terminals causes side shooting which is undesirable in a plant grown for fibre purposes. It is fortunate that the unattacked species, *C. capsularis*, has made generally better growth and to date appears to be more suited to North Queensland conditions.

Figure 1 shows the distortion and damage caused to upper leaves and terminal shoots by the feeding of *R. discopunctulata*. The jute plants were two months old when the photograph was taken, and the number of specimens of *R. discopunctulata* per plant varied from one to ten.

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(*Received for publication April* 23, 1951).

BREEDING AND IMPROVEMENT OF FARM ANIMALS

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(*McGraw-Hill Book Co. Inc., New York*, 1951, *4th Edition*, 787 *pp.*, $7.00)

The fourth edition of the popular American text book on animal breeding is certainly an imposing volume, larger by 36 pages than the third edition. As Professor Rice pointed out in the preface to the third edition, this book is written mainly to serve as a textbook for agricultural students of American universities. For that reason it covers in one single volume a complete course in animal breeding, including reproductive physiology, genetics and the art of breeding. In addition there is an introductory section dealing with the evolution of animals and some historical aspects of animal breeding.

Obviously, such an ambitious plan can be implemented only by treating some of the subjects in a very summarised form. A chapter on statistical analysis, which was included in the third edition, has very wisely been omitted from the fourth. The authors refer instead to Snedecor's excellent text on statistical method. Perhaps some other sections, such as the chapter on milk production, should have been reduced in the same manner to give more space for the discussion of the theory and practice of breeding, and the inclusion of the chapter on selection of wool sheep which is now missing. The book as it is at present mainly discusses the breeding of cattle, horses and pigs. Poultry is completely excluded though probably more genetical work has been done with this important farm animal than any other.

Although the authors have presented a great wealth of scientific data on heredity, variation, methods of selection and mating systems, they still prefer to talk of the art of breeding rather than its science or technique.

Professor Rice has the gift of presenting complicated theories in an easily understandable manner, as in the sections dealing with multiple factors, crossing-over linkage and epistasis. Summaries at the end of each chapter, references, problems, a glossary of Mendelian terms and definitions of most other technical terms given throughout the book will be appreciated by the student-reader.

Whether it is a good idea to discuss the principles of heredity separately from those of variation may be doubtful. Furthermore, although an American book, world-famous geneticists such as R. A. Fisher, Mather and Hagedoorn should be at least mentioned in the text. The value of crossbreeding is not sufficiently discussed and appreciated in the reviewer's opinion, nor does he consider the explanation of heterosis adequate. He would have liked also a more detailed discussion on the value of different breeding systems, such as the Tandem, Total Score and Culling Level methods, the importance of the length of generation interval to the rate of progress in improving farm animals, the minimum number of progeny required to test the breeding value of an animal, and so on.

The chapter written by Warwick on the selection of meat animals is good. The Australian reader especially will find a lot of very useful and up-to-date information in this chapter on the breeding of beef-cattle, pigs and mutton sheep.

In conclusion, it can be said that this is a very comprehensive and modern textbook on the theory and practice of breeding farm animals, which will be appreciated particularly by students and animal breeders who want the whole complex of animal breeding treated in one single book.

F. SKALLER.

ACTI-DIONE* TREATMENT OF CHERRY FRUIT

Introduction

The antibiotic acti-dione is markedly fungistatic to some organisms and fungicidal to others (all of references quoted except Wallen *et al.*) but its use in plant disease control may be seriously limited by its phytoxicity, the extent of which varies with the species and variety (Ford, 1950; Gottlieb *et al.*, 1950; Peterson and Cation, 1950; Wallen *et al.*, 1950).

Peterson and Cation (1950) have shown that in dilutions of 1, 5 and 10 p.p.m. it controlled cherry leaf spot, caused by *Coccomyces hiemalis,* in heavily infected Montmorency trees which had received no fungicidal treatment during the season. Further development of all spots was prevented by 10 p.p.m. acti-dione solutions. Where 1 p.p.m. had been used it was estimated that less than 1 per cent. of lesions were active five weeks after spraying. Cherry foliage appeared to benefit from acti-dione applications but since the work was done after harvesting no information was available as to possible effect on fruit.

Since phytotoxic effects might preclude its use as a spray for the control of cherry leaf spot, work was done to determine whether acti-dione used as a spray, or as a post harvest dip, caused fruit damage, or altered eating and keeping quality. The results of this work are reported here.

Materials and methods

Post harvest dipping

Samples of 50 clean skinned, firm ripe Kentish cherry fruit (*Prunus cerasus*) were dipped in acti-dione solutions containing 1, 5, 10 and 25 p.p.m. in distilled water. Controls were dipped in sterile distilled water. All fruit was dipped for 1 minute and drained on inclined glass surfaces for 1 hour at room temperature (75°F.).

After draining, the fruit was placed in paper lined open trays and stored in a cool cabinet (50°±2°F.) for four days. Following this it was kept at room temperature for a further four days. During this period day temperatures varied from 75-79°F. and night minimum temperature from 70-73°F. Daily observations of fruit condition were made throughout the storage period.

Tree spraying

Since it was not known whether changed environmental conditions would lead to phytotoxic effects only small groups of fruit were sprayed on a single tree of a commercial dark cherry (variety unknown). The tree was sprayed on 22.xii.50 using 1 and 25 p.p.m. aqueous acti-dione solutions. Triton B-1956 was used as a spreader at the rate of 11 ml./500 ml. spray. Controls were sprayed with Triton at the same concentration in water. Approximately 3 hours after spraying a very light shower of rain fell but was insufficient to wash off spray. The weather remained clear and fine until the night of 29.xii.50 when there was a thunderstorm followed by humid weather. As the fruit was ripe, and weather conditions were ideal for fruit spoilage, the crop was harvested and rated on 30.xii.50, eight days after spraying. In the writer's absence, this was done by Dr. W. V. Ludbrook.

Results

In both dipping and spraying experiments it was found that acti-dione had no phytotoxic effects on cherry fruit. Fruit on the tree ripened quite normally and could not be distinguished from either control or unsprayed fruit.

*Trade name for cycloheximide adopted by the Upjohn Company, Kalamazoo, Michigan, U.S.A. The material used in this work was provided by the Research Laboratories of this company.

It was noted after three days of cool storage that a few fruit in each treatment of the dipping experiment showed small brownish coloured patches in the flesh. There was no evidence of injury to or breakdown of the flesh itself. Subsequent inspections and comparison with the controls showed that these patches were due to normal deterioration. After removal from cool storage the rate of deterioration increased in all treatments. On the third and fourth days fruit was rated for deterioration using an arbitrary scale. There was no significant difference between treatments nor any suggestion of a trend in the results obtained.

Dipped Kentish cherries were tasted by nine people. Fruit was taken from randomised dishes. There was no evidence that the taste of the fruit was affected by acti-dione in any way. Fruit sprayed on the tree was also indistinguishable from untreated fruit.

It is of interest to note that in both experiments brown rot (*Sclerotinia fructicola*) appeared on isolated fruit in the control and all treatments. The incidence of the disease was, however, so low that reliable evaluation of the possibility of control by acti-dione could not be made.

Discussion

The results obtained in this work have shown that within the limits of concentration used acti-dione has no phytotoxic effects on cherry fruit. Neither does it affect the keeping quality or flavour.

Provided that there is no human toxicity attributable to spray residue, these characteristics, together with its demonstrated effectiveness at very low concentrations under American conditions should make acti-dione a useful control for cherry leaf spot. Although antibiotics are expensive it is considered that a spray containing 1 p.p.m. acti-dione should be effective and cheap enough to make its use as a spray practicable in the confined areas of Australia where cherry leaf spot is of economic importance.

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(*Received for publication March* 13, 1951.)

CONTROL OF JOHNSON GRASS SORGHUM HALEPENSE (L) PERS. BY SOIL FUMIGATION WITH "D.D."*

This note reports experience in the control of Johnson grass in a black soil by fumigation with "D.D." The trials were carried out at the C.S.I.R.O. Cooper Laboratory, Agricultural College, Lawes, Queensland.

In 1948 it was found necessary to eradicate a small area of Johnson grass in a paddock that was being prepared for planting a mixed pasture of Rhodes grass (*Chloris gayana* Kunth.) and lucerne (*Medicago sativa* L.). The area of infestation was too large for digging, and the normal method of spraying with sodium chlorate was not favoured as it would have delayed sowing for at least a year. At this time Mr. R. Roe (Division of Plant Industry, C.S.I.R.O., Armidale, N.S.W.), in a private communication, advised that he had used "D.D." with success against nutgrass, and it was decided to try this method against Johnson grass. The main advantage of fumigation was, of course, that planting of the pasture would not be delayed.

The "D.D." was placed at a depth of 5 to 6 inches in holes spaced 12 inches apart in parallel rows 12 inches apart, but the holes in adjacent rows were staggered. Approximately 14.4 ml. of "D.D." was poured into each hole from a measure, giving a calculated application rate of 1,500 lb. per acre. This rate was quite empirical. Roe had used 750 lb. per acre in a fine sandy loam, but as it is well known that "D.D." is strongly absorbed by clays, and as the prime objective was to eradicate the Johnson grass, this rate was doubled.

The total area to be treated was divided into six sections which were treated on six days between October 7 and October 25, 1948. In five of these sections the soil was covered with tarpaulins or tarred paper after treatment, and in the sixth the soil surface was watered lightly after treatment. The time of removing covers was staggered so that areas were covered for periods of 5, 11, 14, 20 and 25 days. The total area treated was 3,100 square feet, and the total amount of "D.D." used was 9 gallons, so that the average application rate was 1,232 lb. per acre.

Soil samples were taken for moisture determinations on October 8 and October 19, the results being:—

Depth	Percentage soil moisture	
	October 8	October 19
Surface	7.5	3.0
6 inches	37.9	27.0
12 inches	37.4	32.4
18 inches	37.3	34.1
24 inches	37.4	36.8

No rain fell between these two dates.

The results were excellent. All top growth of plants present before treatment was killed and only 17 plants appeared after the next rain, which was in December. Five of these regenerating plants were excavated and it was found that they originated either from old rhizomes more than 12 inches below the surface, or from pieces of old crowns within the top six inches. These excavations indicated that most of the rhizomes in the top foot of soil had been killed, that some killing had occurred between one foot and two feet, and that there was no effect below two feet. The

*"D.D." is the trade name of a mixture of 1,3-dichloropropylene and 1,2-dichloropropane. It is marketed by the Shell Co. of Australia Ltd.

length of the period of covering had no obvious effect. The ability of portions of crowns to survive and produce adventitious roots appears to be important, and in practice this would necessitate inspection for, and removal of, regenerating crowns about 2-3 weeks after treatment.

The treated area was ploughed on January 17, 1949, cultivated twice, and the pasture mixture was sown on February 26. During this period Johnson grass seedlings were hand pulled on two occasions. Establishment of the pasture species was good and was unaffected by the treatment with "D.D." Since then no Johnson grass has appeared.

Following on the success of this treatment, fumigation with "D.D." without any covering or watering after application has been used repeatedly for spot treatment of Johnson grass in surrounding paddocks and the results have been consistently good.

No experimental work has been attempted to determine the minimum effective rate of application of "D.D.", but these experiences are reported as a matter of interest to those concerned with weed control. For spot treatment of small areas, this method has proved to be much more reliable than spraying with chlorate.

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(*Received for publication September* 10, 1951).

FIELD TRIALS II.—THE ANALYSIS OF COVARIANCE

By JOHN WISHART

(Commonwealth Bureau of Plant Breeding and Genetics Technical Communication No. 15, 1950, *pp.* 35. *Obtainable from technical bookshops or from the C.A.B. Liaison Officer at* 314 *Albert Street, East Melbourne, C.2 Price* 4/5).

Written by the author of *Field Trials: Their Lay-out and Statistical Analysis,* published in 1940 and since reprinted, the present bulletin carries the subject into the domain of those topics which are commonly referred to as comprising the "Analysis of Covariance." The object is to assist the investigator still further in reducing his experimental errors by pointing out how observations made on variates other than those in which he is specifically interested may be used, by means of a special arithmetical technique, in the statistical analysis of his results. In so doing it is necessary to have an understanding of that part of statistical methods which deals with regression and correlation analysis. The object throughout the bulletin is to convey this information in non-mathematical terms, and to present the results in a computing technique which is as simple as it is possible to make it, and which can be followed by the experimenter who is unable to understand a mathematical treatment. Particular attention is directed to Tables 24 and 30, in which all the usual coefficients, including their tests of significance, can be worked out by very simple calculation. All the methods are illustrated by examples.

The two bulletins effectively cover the groundwork of the first half of *Principles and Practice of Field Experimentation,* by J. Wishart and H. G. Sanders, published in 1935 by the Empire Cotton Growing Corporation and for long out of print. But they go much further; in particular the present bulletin deals with the cases of one, two and three affecting variates, and indicates how the methods can be generalised to deal with any number. A novel feature is the treatment of the problem of the difference between regressions in two correlated samples.

THE CITRUS GALL WASP AND SODIUM FLUOROACETATE ("1080")

For many years some interest has been taken in the citrus gall wasp *Eurytoma fellis* Girault, which occurs in the coastal districts of northern New South Wales and southern Queensland. Over the past decade it has been recognised as an economic pest in some Queensland citrus areas. Noble (1933, 1935, 1936, 1938) published detailed reports on the biology and parasites of this wasp, and according to departmental records Queensland entomologists have from time to time worked on the chemical control of the pest. These latter efforts have been directed at killing adults before and during oviposition in the spring, and have not given satisfactory results. This approach has not been fully explored, but is unlikely to yield a solution that would be of general commercial application.

Recently experiments were undertaken to investigate possibilities of killing young wasp larvae before gall formation commenced.

Materials and Method

The stock spray materials used were benzene hexachloride miscible oil with 7 per cent. gamma isomer, bis (bis dimethylamino) phosphonous anhydride ("Pestox III", 66 per cent.), a commercial preparation of E.605 containing 20 per cent. diethyl paranitrophenyl thiophosphate, and "1080" with label assay of "sodium fluoroacetate 90 per cent. minimum, inert ingredients 10 per cent. maximum". These insecticides were used at excess strengths in water, with and without one of the wetting agents "Agral 3" or "Lissapol".

In early January, 1951, badly infested grapefruit trees in the Nambour district were selected. All new growth was heavily scarred at wasp oviposition sites and enlargement of some of the new twigs had commenced. The leaves and twigs of well spaced branches on each of nine trees were sprayed as replicated treatments in a randomised layout. Counts of larvae in sample twigs were taken before, and one week and three weeks after treatment. It was found desirable to make these counts on the day of sampling as the bark stripped more readily when sap was present. Later, inspections for gall formation were made.

Results

Sprays containing sodium fluoroacetate were the only treatments responsible for larval deaths. Three weeks after spraying the over-all kill with sodium fluoroacetate 1:500(w/w), was 60.0 per cent. At the commencement of these experiments most larvae were in shallow pits in the woody tissue, and partially surrounded by nutritive cells. Some of the older larvae in deeper pits, and not in contact with the bark, survived. Eight weeks after spraying growth and foliage appeared normal, and differences in the amounts of gall formation in control and "1080" treatments were obvious.

Discussion

David (1950) has reported preliminary work on sodium fluoroacetate as a systemic and contact insecticide against aphids. These results recorded against the gall wasp warrant still further investigations with "1080" and its mode of action, and open up another approach to a difficult pest control problem.

It is well known that concentrated "1080", like some other commercial insecticides, is highly toxic to mammals but it has already been shown (McDougall, 1949) that the L.D.50 to rats decreases considerably at low poison strengths. Higher kills of gall wasp with the lowest possible dilution and dosage rate should be obtained by spraying some weeks

earlier than the beginning of January. Work on this project is being planned accordingly.

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(*Received for publication May 7, 1951*).

LETTER TO THE EDITOR—

SOIL MICROBIOLOGY IN AUSTRALIA

Sir,

Although one appreciates the need for brevity in a review such as that undertaken by Professor Prescott in your Jubilee Number (1951) it appears to the writer that the section devoted to Soil Microbiology is seriously deficient.

It is doing scant justice to the numerous important contributions of H. L. Jensen to state baldly that he "carried out a series of investigations on nitrogen fixation by soil micro-organisms." It is a fact and should be clearly stated that a large part of Jensen's work, sufficient in itself to establish a world-wide reputation, was carried out for a decade or so before he turned his attention to the study of free-living and symbiotic nitrogen-fixing bacteria.

Professor Prescott also seems to raise some hopes afresh for a significant role by *Azotobacter*. Jensen's detailed studies of this question make it quite clear that there is much more to the matter than presence or absence of the organism. McKnight's findings (1949), to which no doubt Prescott refers, record the relatively frequent occurrence of *Azotobacter* in Queensland black soils but give no quantitative data nor make any claim for its role in nitrogen fixation in the field. The point is an important one because there still remains in some quarters a reluctance to abandon the classical concept of the field importance of non-symbiotic fixation.

Finally, might it not have been reasonable for Professor Prescott to have recorded not only that "research into the effectiveness of these strains (*Rhizobium*) in relation to the host plant promises scope for much future activity" but that it has in fact been actively pursued by several groups of workers in this country.

Yours, etc.,

J. M. VINCENT.

School of Agriculture,
University of Sydney.
10.ix.1951.

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THE SALARY AND STATUS SURVEY OF THE CORPORATE MEMBERSHIP OF THE INSTITUTE

Introduction

This survey of members of the Institute was conducted by the Appointments Board of the University of Melbourne in July, 1950, with the full co-operation of Council and Branch Committees. Copies of a simple questionnaire and covering letter were forwarded to every member of the Institute through the Branch Secretaries, and a response of eighty-one per cent. was achieved. The replies were analysed in detail by the Board and the digest made available to Council. Only a limited distribution of this report has been made to Branches, and due to the rapid changes in salary scales it is considered that publication in full is not now warranted. The following summary presents the principal points.

Qualifications and Type of Work

The most common qualification amongst those who replied to the questionnaire was a University degree in Agricultural Science. In many cases members held more than one degree or diploma, and in this event he was assigned the higher qualification as ranked in order in Table I. Among those possessing qualifications in Agriculture, 26 had qualifications in Science and Engineering and 20 had qualifications in Arts and Social Sciences.

The classification into types of work was made arbitrarily from the information given in the replies. This method was adopted in preference to asking members to indicate one from a prearranged exclusive list of types of work. In many cases the work done by members covers more than one field, and in these cases the main field of activity was chosen. Classification of members by qualification and type of work is given in Table I.

Incomes

The rapid changes recently experienced in salary scales of members employed in state and federal services as well as in other employment

TABLE I.

TYPE OF WORK ACCORDING TO QUALIFICATIONS.

	Higher University Degree in Agricultural Science or Veterinary Science	University Bachelor Degree in Agricultural or Veterinary Science	University Degree in Science or Engineering	Agricultural College Diploma	University Degree in Arts, Economics, Commerce or Education	No Degree or Diploma	Total	Percentage
Research and Investigation—Technical	49	172	37	6	1	5	270	46.9
Research and Investigation—Economic	2	10	—	1	4	—	17	3.0
Administration	27	52	10	12	2	2	105	18.2
Extension and Advisory	6	58	2	12	—	1	79	13.7
Property Investigation and Valuation	—	5	—	1	1	—	7	1.2
Teaching and Academic	14	38	9	—	1	1	63	10.9
Farm Management	—	17	—	3	—	—	20	3.5
Miscellaneous	3	9	—	—	—	—	12	2.1
Not Stated	1	—	—	2	—	—	3	.5
Total	102	361	58	37	9	9	576	
Percentage	17.7	62.6	10.1	6.4	1.6	1.6	—	100.0

have now rendered obsolete the comparative data between services, which was correct at June, 1950, and which otherwise would have been of most interest. However, it is not likely that the relative position of members classified by qualifications or by type of work has been seriously altered, and this data is given in Tables II and III with length of experience as a cross qualification in each case. For the purpose of measuring experience the year of entry into the profession was fixed at the beginning of the year after that in which a member obtained the necessary educational qualifications, except where it is obvious he has gone on to further full-time studies.

TABLE II.

MEAN INCOMES ACCORDING TO QUALIFICATIONS AT VARIOUS LEVELS OF EXPERIENCE.*

Year Ending June, 1950.

	5 Years and Under	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years	31-35 years	36-40 years	41-45 years
Higher University Degree in Agricultural or Veterinary Science	502	836	909	1.021	1,161	1,308	1,772	1,501	—
Bachelor Degree in Agricultural or Veterinary Science	579	747	869	1,032	1,041	1,086	1,413	1,181	—
University Degree in Science or Engineering . ..	670	759	922	959	1,109	817	1,600	1,700	—
University Degree in Arts, Economics, Commerce, Education	—	1,027	980	1,358	—	—	—	1,400	—
Agricultural College Diploma.	—	—	804	859	858	1,243	1,050	962	1,105
General Average ..	579	777	863	1,018	1,071	1,154	1,388	1,233	1,105

*Incomes of those working on their own account have been excluded from this table because of their relatively small numbers and because the wide diversity of incomes make any average almost meaningless.

TABLE III.

AVERAGE INCOME ACCORDING TO TYPE OF WORK.

Type of Work	Years of Experience							
	5 years and under	6-10 years	11-15 years	16-20 years	21-25 years	26-30 years	31-35 years	Over 35 years
Research and Investigation —Technical	569	754	850	968	1,067	1,033	—	1,365
Research and Investigation —Economic	572	808	840	888	—	—	—	—
Administration	697	886	902	1,164	1,116	1,253	1,366	1,032
Extension and Advisory	615	736	789	973	881	1,152	1,500	872
Property Investigation and Valuation	448	840	—	974	830	—	—	—
Teaching and Academic ..	508	727	966	1,006	1,096	1,131	1,500	1,383
Farm Management*	775	772	2,198	760	671	10,000	—	—
Miscellaneous	658	712	728	900	1,225	—	—	—

*Including those working on their own account.

COUNCIL PROCEEDINGS

The 118th Meeting of Council was held at C.S.I.R.O. on Wednesday, September 5, 1951.

PRESENT

Dr. J. G. Davies (in chair). *Principal Delegates*: Mr. L. C. Lightfoot (W.A.); Mr. T. T. Colquhoun (S.A.); Mr. N. E. H. Caldwell (Qld.); Mr. G. C. Wade (Tas.); Dr. I. F. Phipps (Vic.); Mr. E. J. Breawkell (N.S.W.); *Proxy Delegate*: Mr. C. A. Neal Smith.

Proxy Delegates in attendance: Mr. K. Loftus Hills, Mr. C. H. Williams, Mr. W. M. Willoughby, Mr. F. O. Grogan.
Business Manager of the Journal: Mr. J. S. Orr.
Honorary General Treasurer: Mr. A. V. Hill.
Hononary General Secretary: Mr. G. A. McIntyre

Apology

An apology was received from Mr. P. A. Reid, delegate from the A.C.T. Branch, who was unable to attend.

Welcome

The President welcomed the Principal Delegates to this first meeting to be held in accordance with the decision of the 16th General Meeting. He considered that the Institute had made a major step forward, and that regular meetings of principal delegates would result in advances of considerable significance to the Institute and the profession.

Journal

Advertising: The following motion summarising the views of delegates was carried:—

"That the Council recomemnds to the various Branch Committees that consideration be given to the appointment of a member of the Branch to implement an active programme of obtaining further advertising material for the Journal, and the expanding of the circulation of the Journal."

It was agreed that the most satisfactory mechanism would be for these branch representatives to contact the advertising representative via the Business Manager.

Appointment of Assistant Editor:—Council warmly accepted the nomination of Mr. P. F. Butler as Assistant Editor.

Size of Journal: It was generally agreed that the size of the Journal should be increased together with additional advertising.

Salaries and Status Report

It was agreed—

"That the summary of the survey of the profession of agricultural science in Australia be forwarded to the Publications Committee for publication* as soon as possible."

Conditions of employment

It was resolved—

"That support be given to the principle of maximum freedom of transfer between the states and the states and Commonwealth services, and that the Council approves members of branches enlisting the support of other professional bodies whenever the opportunity arises, to further the aims expressed in the resolution of the Brisbane meeting."

Development of the Institute

The principal item for consideration was the determination of the method for allocation of funds to branches for administrative and possibly other expenses.

After some discussion the following motions were carried—

"That a sub-committee be appointed to investigate the allocation of funds from Council to Branches by a formula which takes into account corporate and student membership, the amounts to be available for branch administration."

"That Council may approve additional grants for special purposes, these projects being designed to further the aims and objects of the Institute."

It was also delegated to the above Committee to recommend constitutional changes in the clauses relating to subscriptions, the recommendations to be supported by a budget.

Commonwealth Scholarships

It was reported that Professor Underwood, who had first raised this matter of higher scholarship allowances to students in the honours year, was hopeful that the support which the Institute had given to this proposal would result in something positive being achieved at a university conference to be held towards the end of this year. No further action was taken.

A.I.A.S. Scholarship Scheme

No report has yet been received from Council's sub-committee.

Honorary Membership

Delegates generally felt that long service to the Institute rather than to agriculture, was the important qualification for honorary membership. The question of establishing a limit to the number of members holding this honour at any one time was considered, but the rate of intake to the present, together with the psychological tendency to fill vacancies because they exist ruled out this precautionary measure. The general feeling of the meeting was that although no acceptable precise definition had been achieved, the subject had been very thoroughly ventilated, that delegates had reached a fairly uniform idea of the standard of the honour and that it was unlikely any nomination would be put up in the next few years at any rate that would not find ready acceptance by all branches.

The need for supporting any nomination by adequate documentation was stressed by several delegates.

*This report is published elsewhere in this issue.

Classes of Membership

Delegates elaborated on the branch views recorded in the minutes of the previous meeting.

Dr. Phipps said that it would be necessary to check on the point that "affiliated" membership may disbar the Institute from the privilege of a Royal Charter if sought at some subsequent date. The term used in the Royal Australian Chemical Institute for this class of member was "Subscriber."

Mr. Caldwell said the Queensland Branch felt quite strongly that it would be a false step to open the doors to unqualified persons.

Mr. Wade said that the Tasmanian Branch was definitely in favour of creating this class of membership. The Branch was impressed by a recent experience in a salary re-classification enquiry when it was felt that the general exclusion of diploma people from the Institute lowered the status of the Institute as an effective body in the eyes of the Board.

With the exception of *Mr. Colquhoun*, other delegates were in favour of the proposal to create the new class. It was agreed that discrimination should be exercised in admitting members under this clause and it was desirable that uniformity of opinion be reached even if it was not possible to achieve an exact definition. The clauses governing this class of membership will not be put to the vote before the Annual General Meeting, and in the meantime the Secretary was requested to undertake the job of providing the basis of draft clauses through a questionnaire to branches.

Concessions to Retired Members

The difference of opinion on granting concessions recorded in the previous minutes was maintained. It was generally felt to be a matter of no particular importance, although with the rising subscription and ageing membership it will become more important in the future. It was decided that the questionnaire method of defining clauses be tried as a means to securing a compromise.

The formation of Institute Opinion

Dr. Phipps presented a short report prepared by a Sub-committee of the Victorian Branch on "The Mechanism by which the A.I.A.S. Arrives at an Opinion." Delegates expressed interest in the problem dealt with, but wished to have the report referred to Branch Committees for comment. The Secretary said that copies of the report would be distributed.

Membership

ADMISSIONS

With the recommendation of the Branch submitting the application and of the Qualification Committee, the following applicants were approved for **Corporate** Membership:—

T. I. Leslie	Victoria.
I. H. Cameron	,,
K. D. Gamble	,,
J. L. Patten	,,
A. Righetti	,,
P. Baxter	,,
J. W. Cade	,,
A. Morgan	,,
I. G. Williamson	,,
J. V. Possingham	South Australia.
J. B. Doolette	,,
J. M. George	,,
N. M. Hudson	Tasmania.
G. McBride	Queensland.
C. A. Parker	West. Australia.
E. J. S. Cook	,,
R. W. Bloch	New South Wales.
K. S. Buckley	,,
J. P. Hogan	,,
J. C. Newman	,,
B. E. Mackey	,,
J. Strang	,,
Mis D. E. H. Walker	,,
A. L. Dyce	,,
D. A. Lewis	,,
A. K. Morrison	,,
A. C. Taylor	,,
P. G. Valder	,,
W. E. Wright	,,
R. Powles	,,
H. A. Fraser	,,

Acting on the recommendation of their Branch, the following applicants were admitted to **Student** Membership:—

L. M. Birt	Victoria.
J. P. Brien	,,
A. L. Chapman	,,
G. W. Douglas	,,
I. D. Geard	,,
J. K. Mackinnon	,,
R. G. Paddick	,,
I. D. Peggie	,,
J. S. F. Barker	Queensland.
B. B. Brett	,,
C. S. Brett	,,
L. A. Edye	,,
S. G. Grimmett	,,
J. M. Letchford	,,
R. A. Logan	,,
G. J. P. McCarthy	,,
J. G. Morris	,,
J. H. Southern	,,
R. J. Talbot	,,
Miss C. N. Urquhart	,,

TRANSFER

The following transfer was noted:—

W. C. Duggan—A.C.T. to Victoria

Australian Capital Territory

An ordinary general meeting of the A.C.T. Branch was held on Thursday 6th September and was addressed by Mr. T. T. Colquhoun of the Commonwealth War Service Land Settlement Division, on the subject "The War Service Land Settlement Scheme in South Australia."

In the course of a very informative address, Mr. Colquhoun revealed the highly successful methods used in the development of uncleared scrub land in the Wanilla area of Eyre's Peninsula and on Kangaroo Island in addition to the red gum, rendzina soil and Eight Mile Creek peat areas of the South-East of South Australia.

On Tuesday 30th October, Dr. Ellison addressed a general meeting of the A.C.T. Branch, the subject of his address being "Vegetation, Range Management and Soil Erosion in the Western United States."

Dr. Lincoln Ellison, in charge of Grazing Management Research at the Intermountain Forest and Range Experiment Station, U.S. Forest Service, Ogden, Utah, is visiting Australia for a period of some nine months during the tenure of a Fullbright Fellowship.

While in Australia, Dr. Ellison will be attached to the C.S.I.R.O. Division of Plant Industry and will be engaged in research on pasture ecology in Queensland, having his headquarters at the C.S.I.R.O. Laboratory, Queensland University, Brisbane.

Mr. F. O. Grogan has been appointed to the Branch Committee following the transfer of Mr. W. D. Hardy to Melbourne.

New South Wales

At a general meeting on May 31, 1951, Professor M. J. Sirks of Groningen University, Netherlands, delivered an address on "Genetics, what it has been and will be in the future." The Professor was one of the U.N.E.S.C.O. delegates attending the A.N.Z.A.A.S. Congress which was held in Brisbane this year.

Professor Sirks said that it was with Mendel's work that genetics began although there had been considerable interest in natural variations in individuals of populations before Mendel's time. Real experimentation then lapsed until 1900 when his work was re-discovered by de Vries, Correns and von Tschermak. Bateson, in 1906, gave the name "Genetics" to the new science in which great interest was aroused.

The next period followed the work of Morgan, Muller, Sturtevant and Bridges who showed that, not only did genes exist but that they were located in the chromosomes.

The study of genes in populations or gene geography then commenced. It was found, for example, that some genes occurred in Northern Europe which were completely missing from Southern European populations.

Since 1935, the relation between physiology and genetics has become an important field of research. This work aims at discovering how and at what stage of development the genes affect the individual.

Advances have been made in the study of cytoplasmic inheritance and it is now generally admitted that heredity is influenced by factors located in the cytoplasm of the cell.

In the future, mutations will receive much attention. The causes of mutations, the effect of radiation and chemical substances on the genes will be studied more intensively.

Genetics will continue to play an important part in the improvement of plant and animal populations. There are also institutions devoted to human genetics in relation to the inheritance of diseases and defects.

The main business at the General meeting on July 20, 1951, was an address by Dr. H. C. Forster of the C.S.I.R.O. on "Some Aspects of New Fields of Research in C.S.I.R.O."

Dr. Forster outlined the work of the various divisions of the Organization and then described some particular projects. He dealt more fully with the work of the Land Research and Regional Survey Section. Two major surveys — the Katherine-Darwin region and the Barkly Tableland were described. A sound film on the latter survey was then shown.

The September meeting of the Branch was devoted to an address by Dr. G. L. McClymont on "Recent advances in animal nutrition." The speaker briefly outlined the advances made in the last fifty years in nutritional research.

The speaker concluded by outlining the work of the Glenfield Research Station and stressing the need for trained veterinarians and agriculturists in the field of animal nutrition. A colour film on the cobalt and copper deficiency project in South Australia was then shown.

Queensland

The 91st Ordinary General Meeting was held on the 27th June when Dr. N. T. M. Yeates gave an address on photoperiodicity in sheep. Whilst at Cambridge Dr. Yeates was investigating the possible importance of light as a factor governing breeding activity. Three different light treatment caused 3 groups, each of 12 ewes and 4 rams, to breed at 3 different times of the year, and in each case breeding commenced 10-14 weeks after the change from increasing to decreasing photoperiod. Ten foot candles was sufficient light intensity to bring about these changes.

At the 92nd Ordinary General Meeting on the 26th July, the evening was devoted to notes and exhibits. Mr. W. J. S. Sloane discused recent work in Queensland on fibre plants with special reference to jute. *Corchorus olitorius* has been found to be distinctly inferior to *C. capsularis*

in latitudes 17°-21° south. It appears that jute could be grown in Queensland if suitable machinery were devised for the extraction of fibre. "Kenaf" (*Hibiscus cannabinus*) is perhaps the most promising of the substitute fibres which have been tried in Queensland. Dr. W. A. McDougall outlined a method for evaluating rat poisons which through an intake-toxicity factor correlates cage and field data. Dr. L. G. Miles discussed points that arose at the Cereal Breeders' Conference held at Wagga in July.

South Australia

Dr. S. L. Macindoe addressed a meeting of the branch on 28th September on "Some aspects of crop and pasture investigations being conducted by the Division of Plant Industry, New South Wales Department of Agriculture."

Victoria

Mr. R. D. Croll's presidential address, which had been deferred from the Annual General Meeting, was delivered on August 10, 1951. He took as his title, "Adventures of an agricultural scientist in search of hot water," which enabled him to present some points of view upon the agricultural profession, illustrated by a largely autobiographical background. The speaker was ill at the time of the meeting but resourcefully presented his address by medium of a wire recorder. The talk created considerable interest and was reproduced in full in the Branch Newsletter.

The Annual Dinner of the Branch was held at the William Angliss Food Trades School on September 25, 1951. Chef Zimmerman again demonstrated his calibre and the food was suitably supplemented with those material items and aesthetic features which further promote conviviality. This social function was pronounced an outstanding success.

West Australia

A symposium on "Oestrogenic Hormone Activity in Subterranean Clover and the Sheep Infertility Problem in Western Australia" was presented to members and visitors at the ordinary general meeting of the W.A. Branch on the 17th August.

Professor E. J. Underwood introduced the symposium by outlining the history of the sheep infertility problem in this State. The first section on the Physiological Aspects of Oestrogen Hormones was presented by Miss. J. East. Dr. H. W. Bennetts dealt with Pathological Aspects and supplemented his remarks with a series of lantern slides illustrating the pathological changes in sheep resulting from the ingestion of the clover oestrogen. Dr. D. H. Curnow discussed biological assay of the oestrogen obtained by chemical treatment of dehydrated whole clover. Finally Mr. Rossiter spoke on the Agrostological Aspects of the Sheep Infertility Problem and outlined factors affecting sub-clover dominance in pastures.

PERSONAL

Australian Capital Territory.

Mr. A. J. Anderson, of the Division of Plant Industry, C.S.I.R.O., returned to Australia in May, after twelve months' study leave in the United Kingdom, Europe, Canada and the United States. He also attended the 1950 Commonwealth Agricultural Bureaux Conference in England and the Fourth International Congress of Soil Science in Holland.

Mr. W. D. Hardy has resigned from the Bureau of Agricultural Economics to take up duties in Melbourne as Supervisor of Fresh Fruit Exports.

Mr. G. Paul Phillips recently returned to the Bureau of Agricultural Economics after spending an academic year at Harvard, studying under Professor J. D. Black. He also travelled extensively in Canada and the United States investigating the market outlook research work of the United States Bureau of Agricultural Economics and its practical application in primary industries.

Dr. C. Barnard and *Mr. L. J. Webb* of the Division of Plant Industry, C.S.I.R.O., have recently returned from seven weeks spent in Papua and New Guinea where, with the assistance of the Department of Forests, Papua and New Guinea, they were making a reconnaissance survey of the flora for substances of chemical value and interest.

Sample areas of the lowland, mid-mountain and mountain forests were examined and a number of promising species collected for detailed examination by chemists collaborating in the Australian Phytochemical Survey.

Mr. R. M. Moore, Division of Plant Industry, C.S.I.R.O. returned to Canberra after spending seventeen months in the United States and three months in Great Britain and Europe. Mr. Moore, who was awarded a Fellowship by the Commonwealth Fund of New York, studied plant ecology and related subjects at the Universities of California and Minnesota and at Texas Agricultural and Mechanical College. Returning home via Europe Mr. Moore visited the principal schools of ecology in England, Scotland, Ireland, France, Switzerland and Holland.

Mr. C. M. Donald, Division of Plant Industry, C.S.I.R.O. returned to Canberra after an absence abroad of some seven months. He represented Australia on the pasture committee of the Organization for European Economic Co-operation, an instrumentality of F.A.O., which made a survey of pastures in the Mediterranean region. The survey team, comprising representatives of Great Britain, U.S.A., Australia and South Africa visited Portugal, France, Italy, Greece, Turkey, Morocco, Algeria and Libya. Following the survey, Mr. Donald joined Mr. John Miles of

the C.S.I.R.O. Plant Introduction Section, in a plant collecting trip through the same region.

Mr. J. G. Crawford, Secretary, Department of Commerce and Agriculture recently visited Washington, U.S.A. as Australian representative on the Wool Committee of the International Materials Conference. Since then, he has been in England with the Minister for Commerce and Agriculture, the Hon. J. McEwen, attending the Conference of Commonwealth Supply Ministers and undertaking contract negotiations with the United Kingdom Government for the purchase of Australian primary products.

Mr. C. H. Williams, Division of Plant Industry, C.S.I.R.O., visited New Zealand during March and April this year. About four weeks were spent at the Plant Chemistry Laboratory, D.S.I.R., Palmerston North and in addition, visits were made to other centres where work was in progress on aspects of plant chemistry and soil fertility.

Mr. C. S. Christian, Officer-in-Charge of the Land Research and Regional Survey Section of C.S.I.R.O. recently represented Australia at an F.A.O. conference on Land Utilisation in Tropical Regions. The conference which was held in Ceylon was attended by 41 delegates representing 14 countries in the South East Asia and Far East Regions.

New South Wales

Dr. R. J. Noble, Under Secretary and Director of the Department of Agriculture, was awarded the Outstanding Achievement Award of the University of Minnesota, U.S.A. for 1951.

The position of Reader in Agricultural Economics has been created at the Faculty of Agriculture, University of Sydney, and has been made possible by financial assistance from the Commonwealth Bank. *Dr. K. O. Campbell,* who was formerly Principal Economics Research Officer with the N.S.W. Department of Agriculture has been appointed to the position.

The award of two Thomas Lawrence Pawlett Scholarships has been announced. *Miss Hilary Purchase* will continue her work on Rhizobium at Rothamsted, England, and *Mr. Harland Kerr* will work on the genetics of rust resistance in linseed at Sydney University.

Mr. J. H. B. Christian has taken up duties as a Research Officer in the Division of Food Preservation, C.S.I.R.O., at Homebush.

Mr. D. A. Lewis has been appointed as Field Officer, on the staff of the Batlow Packing House Co-op. Ltd., Batlow, N.S.W.

Advice has been received of an award of 250 dollars to *Dr. D. B. Williams.* It was given by the American Farm Economic Association annually to each of the three most outstanding doctorial theses in the field of Agricultural Economics.

Dr. E. P. Baker, formerly Graduate Research Assistant in the Faculty of Agriculture, has been appointed Lecturer.

Queensland

The 1951 Farrer Memorial Medal was awarded to *Professor L. T. H. Teakle,* Dean of the Faculty of Agriculture, University of Queensland. He delivered the Farrer Oration on "The Role of Nitrogen in Soil Fertility" at Hawkesbury Agricultural College at the conference of the N.S.W. Agricultural Bureau.

South Australia

Dr. C. G. Stephens intends leaving Australia in January, 1952, to take up a three months' appointment with F.A.O., to edit a monograph on soil classification and mapping. His destinations are Rome, United Kingdom and America.

Mr. D. C. Swan is expected to arrive in Australia shortly, after an overseas visit which included America, United Kingdom and Europe.

Mr. N. S. Tiver has been appointed Senior Research Officer in Agronomy in the Department of Agriculture.

Mr. L. J. Cook has been appointed Chief Agricultural Adviser in the Department of Agriculture.

Mr. A. G. Itzerott recently transferred from the Victorian Branch, has been appointed Chief Dairy Adviser in the Department of Agriculture.

Mr. P. G. Schinckel has recently returned to Roseworthy Agricultural College after his overseas trip.

Tasmania

Dr. J. H. Wilson, has recently returned from England where he spent two years at Rothamsted. Shortly after his return it was announced by the University of London that he had been awarded the degree of Doctor of Philosophy for his investigations concerning the growth rate of potatoes in relation to nutrition and virus infection.

Victoria

Mr. C. R. Millikan, Plant Research Laboratory, Burnley, will shortly take the degree of Doctor of Science at the University of Melbourne following the recent approval of a thesis based on his investigations on plant diseases at the plant Research Laboratory. Coincident with the transfer of the Biological Branch from the Agricultural to the Administrative Division, he has been promoted to the position of Senior Plant Pathologist and Deputy Biologist in the Victorian Department of Agriculture.

Dr. T. J. Robinson has transferred from the Western Australian to the Victorian Branch. Following three years abroad at Cambridge and California, he took up at the beginning of this year the newly created position of Senior Lecturer in Animal Physiology in the Faculty of Agriculture, University of Melbourne.

Early this year *Mr. A. G. Itzerott* resigned from the School of Dairy Technology, Werribee, upon his appointment to the post of Chief Dairy Instructor, Department of Agriculture, South Australia.

Mr. W. C. Duggan and *Mr. W. D. Hardy,* both of the Department of Commerce and Agriculture, have transferred from Canberra to Melbourne.

Mr. W. B. C. Mackie has resigned from the Bureau of Agricultural Economics to join the staff of H. J. Heinz Co.

Dr. I. Molnar, formerly Senior Research Officer in the Bureau of Agricultural Economics, Canberra, has been appointed as Senior Research Officer in the Soil Conservation Authority of Victoria.

Mr. G. W. Hexter has resigned from Monsanto Chemicals and has joined the Soil Conservation Authority of Victoria.

Mr. R. R. Hedding has resigned from the Agrostology Section, Department of Agriculture in order to visit Europe.

Mr. P. F. Butler, formerly of the Waite Institute, is now with C.S.I.R.O., East Melbourne. He has recently taken on the honorary post of Assistant Editor of this Journal.

Mr. R. R. Pennefather has transferred to the Victorian Branch following his resignation from the Irrigation Research Station, Griffith, N.S.W. and appointment as Officer-in-Charge of the Agricultural Research Liaison Section, C.S.I.R.O.

OBITUARY

WALLIS VERCO LUDBROOK

We regret to record the death in Canberra on August 18, 1951, of Dr. Wallis Verco Ludbrook, Senior Microbiologist of the Division of Plant Industry, C.S.I.R.O.

Wallis Ludbrook was born in South Australia in 1904 and was educated at Roseworthy Agricultural College where he was Dux in his first year, Adelaide University and the University of Wisconson, U.S.A. He served in the R.A.A.F. in the second World War.

He joined the staff of the Division of Plant Industry in 1929 and after a few months he proceeded on a Senior Research Studentship to the Department of Plant Pathology at the Univirsity of Wisconsin where he did post graduate study and research towards the degree of Doctor of Philosophy.

Dr. Ludbrook's researches were chiefly concerned with *Verticillium* hadromycosis, take-all of wheat, needle fusion and other disorders and diseases of *Pinus spp.*, root and top rot of maize, scab and late blight of potato, bare patch of sub-terranean clover at Keith, S.A., dollar spot and other turf diseases. To our knowledge of these diseases he made significant contributions. He was devoted to his work, which was executed with meticulous attention to detail and with characteristic thoroughness. He was often to be seen at work on holidays, week-ends and evenings.

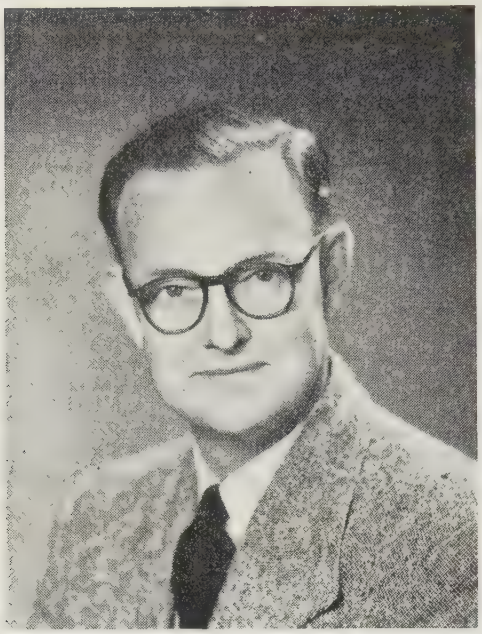
Wallis was held in the highest esteem by his associates in the laboratory and other agricultural organizations. Although reserved he had a keen sense of humour. He was a lover of the solitude of the pine woods, mountains and trout streams, of music and art.

R. M. STEPHENS

Mr. R. M. Stephens, B.Sc., a member of the Victorian Branch, died at the age of 36 on September 8, 1951, following a short illness. He was a graduate of Melbourne University where he did a sound and wide science course, majoring in three subjects. In 1939 he joined Vacuum Oil Company, where he was in charge of chemical work concerned with biological products and did notable work on control of wheat weevil, peach aphis and peach curl. In 1945 he joined the staff of the Plant Research Laboratory, Burnley and was active in the Rutherglen bug outbreak, the testing of D.D.T. sprays against codlin moth under Goulburn Valley conditions and took part in the 1946 anti-locust campaign. From 1948 until his death, he was biochemist at the School of Dairy Technology, Werribee, but his wide knowledge led him to play a role in engineering and other branches of dairy technology as well. One aspect of this was his help in advising the Milk Pasteurization Committee. He was highly respected by his colleagues who deeply regret the loss of an outstanding scientist and friend.

THE AUSTRALIAN MEDAL OF AGRICULTURAL SCIENCE

AWARD TO E. A. CORNISH



The Institute Medal for 1951 has been awarded to Dr. E. A. Cornish, B.Ag.Sc., D.Sc., who is well known both in Australia and overseas for his work on the statistical treatment of data affecting agricultural production. Dr. Cornish, who is now in charge of the Section of Mathematical Statistics, C.S.I.R.O., formerly held the position of Agronomist at the Waite Agricultural Research Institute.

His earlier work dealt with some of the more complex experimental designs and were written to show how their unequivocal and exact treatment could be developed. By use of orthogonal polynomials, he made a remarkable discovery as to the history of the weather in South Australia, and from this interest his most fruitful studies developed. These have dealt with the problems of production in the wheat belt of South Australia and are covered in two comprehensive papers published in 1949 and 1950 on "Yield trends in the wheat belt of South Australia, 1896-1941" and on the "Influence of rainfall on yield of wheat in South Australia." These papers reveal perseverance and capacity to accomplish a heavy task.

The agricultural implications of Dr. Cornish's findings concerning yield trends in different parts of the wheat belt are best summarized in his own words:—

"The wheat belt is broadly divisible into three parts—

(1) Sandy, stony and mixed mallee soils and related types in which nitrogen becomes limiting after 20-40 years of cropping, and yields subsequently decline owing to exhaustion of the reserves.

(2) Loamy mallee soils and red brown earths, where yields increased over the period 1896-1941, but at diminishing rates as nitrogen becomes limiting.

(3) Sandy and loamy mallee and transitional mallee-solonetz soils, where yield increases linearly throughout, mainly because exploitive cropping has not been in progress long enough to make its influence apparent. These regions constitute only a small proportion of the total area."

These conclusions have surely defined a crucial and fundamental problem in this country — the problem of declining fertility in our wheat lands.

In his paper of 1950 the relationship between the yield of wheat and seasonal rainfall has been determined, the seasonal rainfall being represented by the rains in three subdivisions of the growing period of the crop. This paper provides a clear demonstration of the sub-optimal character of average seasonal rainfall over the greater part of the season and almost throughout the wheat belt of South Australia.

R. E. SOUTTER—HONORARY LIFE MEMBER

The award of Honorary Life Membership in the Australian Institute of Agricultural Science to Richard Ernest Soutter comes as a fitting tribute to a career of splendid service to Australian agriculture.

Mr. Soutter was a foundation student of the Queensland Agricultural College at Gatton, and later was appointed as Horticulturist at the Westbrook State Farm on the Darling Downs. Always keenly interested in plants and particularly in hybridization it was at Westbrook that he laid the foundation of his life's work. Here, in 1898, he made his initial crosses with this crop.

In 1905 he was transferred to the Maranoa district to supervise wheat demonstration plots in marginal areas, and in 1906, he was appointed Manager of the Roma State Farm. Working under primitive conditions, he bred a series of excellent wheats which provided the foundation of Queensland's thriving wheat industry.

Under the dry conditions of the Roma district, none but the hardiest combinations survived, and drought resistance thus became one of the major attributes of the wheats which he bred. High gluten quality was another objective in Mr. Soutter's work, and by the constant use of such parents as Florence, Pusa 4, Bobs and Comeback, he has been able to maintain in his varieties a standard of quality unexcelled elsewhere in Australia. Resistance to both stem rust and leaf rust has also been sought, and was partially achieved in such varieties as Three Seas and Seafoam. Moreover, at the time of his retirement in 1948 he was able to hand over to his successor a wide range of hybrid selections showing virtual field immunity to both species of rust.

Flora (from Florence x Bobs) was Mr. Soutter's first successful commercial

variety. It was Flora which won for its creator both Commonwealth and international awards during the 1930's. Important later varieties of his breeding are Puora, Puno, Puseas, Warput and Lawrence.

In 1935 Mr. Soutter was transferred to Brisbane, from which centre he continued his wheat breeding at selected sites on the Darling Downs. In 1948, he retired from the Department of Agriculture and Stock accompanied by the highest tributes from his colleagues and from representatives of the farming, milling and baking industries. The young hybridist of 1898 had lived to see the day in which over 80 per cent. of his state's wheat acreage was devoted to varieties of his breeding. This was the culmination of an achievement of which any man might well be proud.

R.G.M.

NEWS ITEMS

Conference of Agronomists—Adelaide, Sept., 1951

This conference of agronomists, which was attended by officers of state and Commonwealth departments, was convened in the terms of a decision of the Australian Agricultural Council. In view of the serious position in regard to future superphosphate supplies, its object was to enable the greatest amount of information to be obtained from phosphatic fertilizer trials, in the light of existing information and Australia-wide requirements.

An outline of the superphosphate supply position was presented by the Department of Commerce and Agriculture.

Past experimental work over the whole of Australia was reviewed, showing the general superiority of superphosphate over several other forms of phosphate for all crops and pastures, especially where heavy phosphate dressings had not been applied.

With regard to current phosphate trials it was considered that the most useful way of co-ordinating the existing work was to standardize on the data to be collected.

In addition to existing trials, conference mapped out phosphate experiments on an agricultural regional basis and made suggestions concerning the design of such experiments. Arrangements were made for the collation of data from all relevant existing and future experiments.

Conference of Cereal Breeders and Geneticists

Under the auspices of the Australian Agricultural Council a conference of cereal breeders and geneticists was held at the Wagga Agricultural College in July. After the formal sessions the delegates spent a day at the Sydney University discussing various aspects of the plant breeding work.

The N.S.W. Department of Agriculture and the C.S.I.R.O. were responsible for the organization of this conference which was attended by 40 delegates.

The proceedings will be published by C.S.I.R.O. in roneoed form.

School for Sheep and Wool Extension Officers

From 10th-14th September more than 30 sheep and wool extension officers from all mainland states attended a school conducted by the Queensland Department of Agriculture and Stock in association with C.S.I.R.O. Lectures were also given by officers of the N.S.W. Department of Agriculture and the East Sydney Technical College. Research officers presented latest results of work on reproduction and lamb losses, wool biology, nutrition and drought feeding and selection. Basic data were included in a handbook prepared for the school by the Agricultural Research Liaison Section of C.S.I.R.O.

Tatura Horticultural Research Station

Recently the Victorian Government approved of the erection at the Tatura Horticultural Research Station of a laboratory and office building at a cost of £20,000 and staff quarters at a cost of £7,500. The Station deals mainly with the cultural problems of canning peaches, pears and apricots under irrigation. Established in 1937, its findings are now having a marked influence on orchard management in the Goulburn Valley.

Establishment of a New Agricultural College

It has been announced that the Victorian State Government will establish an agricultural College at Glenormiston in the Western District. This College will offer a diploma course in dairying.

New Dairy Husbandry Research Centre in Victoria

At Ellinbank, near Warragul, work will begin on the development of a Dairy Husbandry Research Centre on the 365 acres purchased there by the Victorian Department of Agriculture. The programme includes subdivision of the farm into four experimental dairy units, provision of laboratory facilities for chemical and bio-chemical investigations supplemenetary to the field work, as well as facilities for veterinary diagnostic work.

Inter-Commonwealth Post-Graduate Scholarships In Science

The Royal Society Empire Scientific Conference and the British Commonwealth Scientific Official Conference in 1946 recommended the preparation of a list of post-graduate scholarships available for scientific study within the Commonwealth. The task of compiling the list was assigned to the British Commonwealth of Nations Scientific Liaison Offices in London.

Since the main objective of the list is to encourage the movement of scientists within the Commonwealth, only those awards open to members of at least one Commonwealth country or Colony other than the awarding one have been included.

The entries are set out in tabular form showing, in addition to the names of the scholarships and the agencies awarding them, details of the fields of study, where tenable, duration and value, closing dates for applications and the addresses to which these should be sent. There are more than 350 separate entries in the list: many of these cover a number of scholarships so that the total number of available awards is much greater. The list is therefore a valuable work of reference for students and educational authorities.

It is published on behalf of B.C.S.O. (London) by His Majesty's Stationery Office. The price (6/3d. Australian) has been fixed at the lowest possible level having regard to present publishing costs in an endeavour to bring the document within the reach of University students throughout the Commonwealth.

The list is on sale in the United Kingdom at all branches of H.M. Stationery Office and in Australia it may be obtained through their agents whose names and addresses are listed below:

Angus and Robertson Ltd., 89 Castlereagh Street, Sydney, N.S.W.

McGill's News Agency, 183-5 Elizabeth Street, Melbourne, Victoria.

Oldham, Beddome and Meredith (1932) Pty. Ltd., 36 Elizabeth Street, Hobart, Tasmania.

The Graham Book Co., Prudential Building, Martin Place, Sydney, N.S.W.

BOOK REVIEWS

THE ESTABLISHMENT OF VEGETATION ON INDUSTRIAL WASTE LAND

By R. O. WHYTE and J. W. B. SISAM

(Commonwealth Agricultural Bureaux Joint Publication No. 14 1949, pp. 78. Obtainable from technical bookshops or from the C.A.B. Liaison Officer at 314 Albert Street, East Melbourne, C.2. Price 12/6.)

This publication is the outcome of a study of the problems and techniques of reclamation of industrial waste land by the establishment of vegetation, the majority of the information having been collected from unpublished sources.

Reclamation can be accomplished by the slow natural process of ecological succession, commencing with "pioneer plants," those herbs, shrubs and trees with very low nutritional requirements. On the other hand the problem may be dealt with by improving the soil environment first, and artificially establishing vegetation. It is obviously preferable to accelerate the former process whenever possible.

The first chapter is devoted to descriptive matter on the extent of the problem in the United Kingdom, the U.S.A., Germany, France, South Africa and Cyprus.

In the United Kingdom it is shown that in some districts the amount of wasteland may be considerable, no less than 12.8% of the Black Country falling into this category. Both mining and industrial waste material contribute to the creation of devastated and derelict wasteland in the form of spoil banks from coal and iron ore mining (particularly of strip or open-cut mining), deposits of slag, ash and cinders, as well as quarrying, brickworks and similar activities.

It is estimated that in excess of 100,000 acres have been devastated in the anthracite region of Pennsylvania, U.S.A., by the open-cut method. Successful efforts to reclaim such land have already been made by the planting of *Robinia Pseudoacacia*, red, Scots and jack pines.

A short chapter on types of wasteland and their classification is followed by a discussion on the factors affecting the treatment of such areas including the objectives of reclamation, that is for landscape improvement, stabilization or to provide economic returns by way of timber production or grazing value. It will be apparent that the difficulty of re-vegetating such spoil areas lies in the unfavourable habitat offered to plant growth. Industrial waste will frequently present toxic conditions, while spoil mounds are usually deficient in nutrients, often highly acid, and require a period of weathering before providing a soil upon which even the most hardy plants will grow.

The establishment of vegetation naturally is next treated, and examples of colonization and succession are given. Under favourable conditions re-vegetation may commence within a year or so, but is on the whole a slow process.

Considerable information is then given on the establishment of vegetation by artificial means. Species of trees and shrubs which have proved suitable in various countries, under diverse conditions are indicated, and alternative establishment techniques described. Examples of the establishment of grazing or pasture mixtures in Great Britain and the United States and the techniques adopted are discussed.

The final chapter is devoted to the surveying of derelict land with a view to its reclamation indicating the points which should be noted regarding its physical nature (detailed soil analyses are not considered).

A bibliography of published and unpublished references is appended, and an index to species mentioned in the text, together with a list of common names which have been used freely. The publication is profusely illustrated with a series of excellent photographs, and should prove invaluable to organizations faced with reclamation problems. It will appeal to the popular as well as the technical reader.

D. A. N. CROMER.

CATALOGUE OF INSECTICIDES AND FUNGICIDES COMPILED BY DONALD E. H. FREAR.

VOLUME II. CHEMICAL FUNGICIDES AND PLANT INSECTICIDES

(Chronica Botanica, Waltham, Mass., U.S.A. and N. H. Seward, Melbourne, C.1, 1948, 153 pp., $ 5.50).

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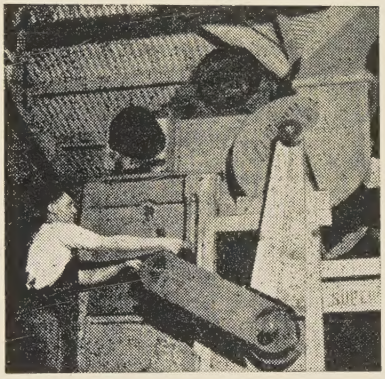

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Printed for the Australian Institute of Agricultural Science by Ramsay, Ware Publishing Pty. Ltd., 129 King Street, Melbourne.